MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LXXXII. FEBRUARY 10, 1922. No. 4

ANNUAL GENERAL MEETING.

Professor EDDINGTON, F.R.S., PRESIDENT, in the Chair.

The Minutes of the preceding Annual General Meeting were read and confirmed.

The Report of the Auditors of the Treasurer's accounts for the year 1921 was read, and is given on p. 238.

The Annual Report of the Council was partly read.

The Address was delivered by the President, after which the Gold Medal was handed to Dr. James Hopwood Jeans, to whom it had been awarded for his contributions to the Theories of Cosmogony.

The President having appointed the Scrutineers, the Society proceeded to the ballot for Officers and Council for the ensuing year. The names of those elected are given on p. 289.

Colonel Grove-Hills explained that immediately on being informed by the President that the Council wished him to come forward for election to the office of Treasurer he had carefully gone into the question of the finances of the Society.

It was clear that, mainly owing to the great rise in the cost of printing, the income of the Society did not now cover the expenditure, and that if full power of publication were to be maintained it was

urgent that some action should be taken without delay. He had therefore approached a few Fellows and obtained gifts from them, amounting to about £600, to form the nucleus of a fund designed to tide the Society over the next four or five years, by which time it was to be hoped that prices would have come down and more permanent measures could be taken.

The Council had approved his action, and authorised him to proceed with the collection of a Special Fund.

He estimated the total amount required as about £1800, and he now earnestly appealed to all Fellows and Associates to assist, to the utmost of their ability, with donations to this Fund.

He also pointed out that the best way of ensuring the solvency of the Society was by an increase of membership, and he strongly urged all Fellows to lose no opportunity of getting suitable new candidates to come forward.

The thanks of the Meeting were given to the retiring Members of Council, and also to the Auditors of the Treasurer's accounts and to the Scrutineers of the ballot.

Lieut. Gordon Dixon Brown, R.N.R., The Shack, Dolvin Road, Tavistock, S. Devon;

Arnold Buxton, M.A., Senior Lecturer, Mathematics Dept., Technical College, Cardiff;

Herbert Dingle, Lecturer on Astrophysics, Imperial College of Science, S. Kensington, 21 Queen Elizabeth's Walk, Stoke Newington, London, N. 16;

Commander Donald Dowdy, R.D., R.N.R., 1 Cannon Court, Brighton, Sussex;

Alfred Charles Gardner, M.Inst.C.E., F.G.S., West View, Healing, Lincs.;

Dr. Henri Nort, Krugerlaan 3, Gouda, Holland;

Egon Sharpe Pearson, B.A, 7 Well Road, Hampstead, London, N.W. 3;

Bertrand M. Peek, M.A., Gorse Cliff School, Boscombe, Bournemouth; and

Inkerman Rogers, F.G.S., 38 Tudor Road, Kingston Hill, Surrey,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

Ronald Edward Beare, Nautical Instructor, 16 Newcombe Road, Southampton (proposed by W. G. Gilchrist);

Rev. William Edwards, The Manse, Caerau, near Bridgend, Glamorganshire (proposed by M. Proctor);

Rev. John Hixon Irving, Cressington Avenue, Higher Tranmere, Cheshire (proposed by W. Phillips);
Richard Marshall, F.R.Met.Soc., 118 Ribblesdale Road, Streatham, London, S.W. 16 (proposed by Harold Jeffreys);
Mrs. Howard Pease, Otterburn Tower, Otterburn, Northumberland (proposed by E. H. Grove-Hills); and
Rev. John Henry Wilkins, M.A., D.D., Westbury on Trym, Bristol (proposed by I. T. Warner-Staples).

Report of the Council to the Hundred and Second Annual General Meeting of the Society.

The following table shows the progress and present state of the Society:—

	Patron	Honorary Member	Fellows		Associates	Total
			Compounders.	Annual Subscribers		
1920 December 31	1	1	230	511	48	791
Since elected	...	...	+ 7	+45	+4	...
Deceased	...	...	−12	−16	−3	...
Resigned	...	...	...	− 4	...	...
Since compounded	...	...	+ 3	− 3	...	...
Removed from list	...	...	...	− 6	...	...
1921 December 31	1	1	228	527	49	806

(Five Associates are also Fellows, and are therefore counted twice in the above table.)

Mr. Knobel's Account as Treasurer of the Royal

RECEIVED.

	£ s. d.	£ s. d.
Balances, 1921 January 1:—		
At Bankers', as per Pass-book	24 12 10	
In hand of Assistant Secretary on Petty Cash Account	11 7 7	
In hand of Assistant Secretary on account of Turnor and Horrocks Fund	1 3 9	
		37 4 2
Cheque not paid in last year		2 2 0
Received on account of Dividends:—		
£1,250 Metropolitan 3-per-cent. Stock	37 10 0	
£2,000 Swansea Corporation 3½-per-cent. Stock ...	70 0 0	
£3,500 East Indian Railway 3-per-cent. Debenture Stock	73 10 0	
£3,500 London and North-Western Railway 3-per-cent. Debenture Stock	73 10 0	
£4,000 Midland Railway 2½-per-cent. Debenture Stock	70 0 0	
£1,000 Lancashire and Yorkshire Railway 3-per-cent. Preference Stock	21 0 0	
£2,400 Gas Light and Coke Co. 3-per-cent. Debenture Stock	50 8 0	
£2,000 Commercial Gas Co. 3-per-cent. Debenture Stock	42 0 0	
£1,352, 12s. 6d. War Loan Inscribed 5-per-cent. Stock	67 12 6	
£275, 16s. 0d. War Loan Registered 5-per-cent. Stock	13 15 8	
£542, 18s. 2d. India 3½-per-cent. Stock	16 3 0	
		535 9 2
Received on account of Subscriptions:—		
Arrears	130 4 0	
Annual Contributions for 1921	812 14 0	
,, ,, ,, 1922	10 10 0	
Admission Fees	107 2 0	
First Contributions	71 8 0	
		1131 18 0
Compositions		264 12 0
Sales of Publications:—		
At Society's Rooms	30 5 8	
At Wheldon & Wesley's £265 11 7		
Less 10 per cent. discount ... 26 11 1		
	239 0 6	
Herschel's Works: half share, received from the Royal Society	3 1 3	
Franklin-Adams Charts	460 0 0	
		732 7 5
Sales of Photographs		94 1 0
Income Tax refunded		163 8 6
Proceeds of Sale of £275, 16s. 0d. 5 per cent. War Loan Registered Stock (Sir D. Gill's Bequest)		241 13 0
Carnegie Grants towards expense of *Memoirs*, vol. 63 ...		200 0 0
London Mathematical Society, for use of Rooms, etc. ...		20 0 0
Central Asian Society, for use of Room for Meeting ...		1 1 0
Due to Assistant Secretary on Account of Turnor and Horrocks and Harry Watson Funds		18 5 4
Debit Balance at Bankers', 1921 December 31		8 10 9
		£3,450 12 4

Examined and found correct.
(Signed) W. H. STEAVENSON.
FRANK ROBBINS.

1922 *February* 3.

Astronomical Society, from 1921 *January* 1 *to December* 31.

PAID.

	£ s. d.	£ s. d.
Assistant Secretary: Salary	250 0 0	
,, ,, Editing Society's Publications ...	50 0 0	
Extra clerical assistance	42 16 5	
Clerk: Salary	155 0 0	
Porter and wife: Wages	174 7 0	
		672 3 5
House Duty	2 12 6	
Fire Insurance	10 13 0	
Insurance of Stock at Printers'	1 18 3	
Insurance of Portrait of Sir D. Gill	0 9 0	
Accident Insurance	1 0 9	
Servants' Insurance Stamps	2 3 4	
		18 16 10
Printing, etc.:—		
Memoirs, Appendix to vol. 62	36 11 3	
Memoirs, vol. 63	573 18 6	
Monthly Notices, 8 numbers	911 9 9	
List of Fellows and Miscellaneous	107 13 9	
Photo-engraving	56 17 3	
		1686 10 6
Reproduction of Photographs for sale		79 12 10
Cost of preparation of Franklin-Adams Charts		568 16 9
Turnor and Horrocks and Harry Watson Funds: Purchase of Books for Library		34 9 1
Expenses of Meetings of R.A.S.	19 15 10	
Expenses of Geophysical Discussions	9 8 3	
Time Signal: Rental of Wire	5 2 8	
		34 6 9
Telephone: Subscription, Deposit, etc.	9 11 10	
Registration of Telegraphic Address	2 0 0	
Postage, etc. (including postage of *Memoirs* and *Monthly Notices*)	134 8 11	
Carriage of Parcels	1 4 2	
Stationery and Office expenses	18 14 4	
Purchase of Scarce Numbers of *Monthly Notices*	0 10 0	
Binding for Library	2 17 6	
		169 6 9
House expenses	9 12 7	
Coal, Gas, Electric Light, etc.	95 5 0	
Sundry Fittings and Repairs	20 7 11	
Sundries	5 5 8	
		130 11 2
Subscription Conjoint Board of Scientific Societies ...	10 0 0	
Lee and Janson Fund Grant	12 0 0	
Assistant Secretary for work for London Mathematical Society	10 0 0	
Expenses of Meetings of London Mathematical Society ...	7 3 10	
		39 3 10
Cheque Book and Bankers' Charges on Cheques	1 1 2	
Deficiency on French P.O. Order	0 0 5	
		1 1 7
Cheque outstanding, 1921 January 1	3 0 0	
Cheque outstanding, 1921, December 31	3 3 0	
Balance in hand of Assistant Secretary on Petty Cash Account	8 19 8	
		15 2 8
Interest on Overdraft at Bankers'		0 10 2
		£3,450 12 4

Report of the Auditors.

We, the undersigned, appointed Auditors by the Fellows assembled in ordinary meeting 1921 December, now report that we have examined the Treasurer's accounts of receipts and expenditure for the calendar year 1921, and have found and certified the same to be correct. The accounts are well kept.

The cash in hand on 1921 December 31 was:—petty cash, a credit balance £8, 19*s.* 8*d.*, on Turnor and Horrocks Funds a debit balance £18, 5*s.* 4*d.*, with a debit balance £8, 10*s.* 9*d.* on the bank account. Or all together a debit balance £17, 16*s.* 5*d.*

The income for the year amounted to £1820, 14*s.* 11*d.*, and the expenditure to £2134, 7*s.* 3*d.*; that is to say, the expenditure of the Society exceeded its income by the considerable amount £313, 12*s.* 4*d.* Ten composition fees amounting to £264, 12*s.* were received.

The income tax deducted at the source has been refunded by the Commissioners of Inland Revenue up to and including 1921 April 5. Between that date and the end of the year £87, 13*s.* 6*d.* has been deducted, and this appears among the assets.

A further sum has been received from the Royal Society in consideration of the sale of three sets of Sir William Herschel's collected papers. This account shows a debit balance of, say, £250.

The publication of vol. lxiii. of the *Memoirs* has necessitated the sale of that portion of the holding in War Loan £275, 16*s.* which was acquired by means of Sir David Gill's bequest (£250). This realised £241, 13*s.* in November—a loss of 3·34 per cent. Towards the cost of this volume a generous contribution of £200 was received from the Carnegie Fund, and the balance, £132, 5*s.* 6*d.*, came out of the general fund.

The cost of the first eight parts of *M.N.*, vol. lxxxi., appears in the accounts as £911, 9*s.* 9*d.* = £1·577 per page.

We are able to say that the Library is in satisfactory order, but the following books are known to be missing:—

Laplace, *Traité de Mécanique Céleste.* Vol. v., 4to. Paris, 1825.
Maunder, E. W., *The Royal Observatory, Greenwich.* 8vo. London, 1900.
Webb, T. W., *Celestial Objects.* 5th ed., 2 vols. 1893–94.
Namur, A., *Tables de Log. à 12 décimals.* 8vo. Bruxelles, 1877.
Poincaré, H., *Leçons de Mécanique Céleste.* Vol. ii., 8vo. Paris, 1907–9.
Struve, F. G. W., *Etudes d'Astronomie Stellaire.* 8vo. St. Petersburg, 1847.

The MS. tables of twelve place logs of natural numbers computed by John Thomson of Greenock (described in *M.N.*, vol. xxxiv., part 9) has been out on loan forty-seven years. Its return was promised in 1909.

We have given the usual statement of the investments in tabular form, from which it will be seen that the depreciation at the end of 1921 amounted to £9400, or about 44 per cent. The interest yield is £3, 2*s.* 8*d.* per cent.

We are sorry that the Lee and Janson Fund and the Hannah Jackson

Fund are merged in the general investments. It would conduce to simplicity if trust funds of such a special character could have been kept distinct.

The number and amount of subscriptions due and overdue is given in the usual form: in the past it has not been found possible to collect these entirely.

The outstanding account for printing *M.N.*, vol. lxxxi., part 9, and vol. lxxxii., parts 1 and 2, is estimated to amount to £200.

It has been customary of late years to mention but one liability, viz. the amounts of subscriptions received a year in advance. To be consistent, the case of the 233 compounders who have paid n years in advance should be stated. In the absence of any information as to their attained ages, an exact valuation is out of reach. We have assumed the mean age 45 or 50, and with this as argument we find (from the published tables of the National Debt Office) as a first approximation six or seven thousand pounds as the value of this liability.

In 1904 our compounders were in the proportion 10 to 14 annual subscribers. Since that time the ratio has fallen steadily, and at the middle of 1921 it stood at 10 to 22. Knowing that the compounder seldom bears his full share of the financial burden of maintaining our Society, we regard with approval this change.

We have no animus against the compounder—we are simply discontented with the present unscientific flat rate for all ages. The amount of purchase money for a life annuity under the National Debt Office is based on (*a*) the rate of mortality experienced by Government annuitants during a century, (*b*) on the current rate of interest, (*c*) and on sex, because women live longer than men.

So far neither discussion nor meditation has revealed any justification of the Society's anomalous system.

We have examined the account of each compounder deceased in 1911–21. The results being too long for this report, will be exhibited to the General Meeting by means of lantern slides. They seem to justify the suggestion now made, that the Bye-Law No. 23 regulating the admission of compounders be suspended while a small committee of the Council considers the results already obtained under the new scheme (1903).

In this investigation we received valuable assistance from Miss V. M. Common, who searched the archives and supplied the requisite data.

As regards the instruments, we think it is necessary to mention the $3\frac{1}{4}$-inch Ross equatorial refractor, No. 133; under Regulation V. paragraphs Nos. 1 and 3 are being relaxed herein. This telescope has been out on loan for over twenty-three years.

A list has been laid on the table of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting of the Society, with the amount due against each Fellow's name.

The certificates of railway and other stocks have been examined, and the stocks inscribed at the Bank of England verified.

(Signed) W. H. Steavenson.
Frank Robbins.

1922 *February* 10.

Stock.			Date of Purchase.	Total Cost.			Cost per cent.	Value at 1921 Dec. 29.	Yield (per cent.			Total Interest.		
£	s.	d.		£	s.	d.		£	£	s.	d.	£	s.	d.
1250	0	0	Metropolitan Cons., 3	1883–90	1254	8	0	100·352	856	2	19	9	37	10	0
2000	0	0	Swansea Corp., 3½	1905–9	2136	10	3	106·825	1200	3	5	6	70	0	0
3500	0	0	East India Rlwy., 3	1899–1909	3576	17	6	102·196	1663	2	18	8	105	0	0
3500	0	0	Lond. N.W. Deb., 3	1899–1908	3871	8	0	110·623	2030	2	14	3	105	0	0
4000	0	0	Midland Deb., 2½	1899–1901	3750	5	3	93·757	1880	2	13	4	100	0	0
1000	0	0	Lanc. and Yorks Pref., 3	1903–10	867	11	0	86·755	560	3	9	2	30	0	0
2400	0	0	Gas Light and Coke Deb., 3	1899–1913	2328	2	10	97·006	1224	3	1	10	72	0	0
2000	0	0	Comm. Gas Deb., 3	1899–1910	1899	0	9	94·952	890	3	3	2	60	0	0
19,650	0	0			19,684	3	7	100·174	10,303	2	18	10	579	10	0
1,352	12	6	War Loan, 1929–47, 5	1915–9	1,282	7	3	94·805	1248	5	5	5	67	12	7
542	18	2	India Stock, 3½	1920	300	0	0	55·258	315	6	6	8	19	0	0
21,545	10	8			21,266	10	10	98·705	11,866	3	2	8	666	2	7
									9,400						
									Depre-ciation						

Gifts to the General Funds of the Society.

In 1836 John Lee, Esq., LL.D., gave the Advowson of the living of Hartwell; in 1844 he gave the Advowson of the living of Stone, Bucks. In 1879 these Advowsons were repurchased by his heir, Edward Lee, Esq., for £700.

The Lawson Bequest (1856): Henry Lawson, Esq., bequeathed to the Society the sum of £200, free of legacy duty.

The Carrington Bequest (1876): R. C. Carrington, Esq., F.R.S., bequeathed to the Society £2,000 Consols.

The Lambert Bequest (1877): C. J. Lambert, Esq., presented to the Society the sum of £500, free of legacy duty, being part of a sum of money bequeathed by his father, Charles Lambert, Esq., for scientific purposes.

The McClean Bequest (1905): Frank McClean, Esq., LL.D., F.R.S., bequeathed to the Society the sum of £2,000, free of legacy duty.

The Farrar Bequest (1906): The Rev. A. S. Farrar, D.D., bequeathed to the Society the sum of £100, free of legacy duty.

Trust Funds.

The Lee and Janson Fund: In 1834 John Lee, Esq., LL.D., gave £100, and in 1876 T. C. Janson, Esq., bequeathed £200, the interest to be given to the widow or orphan of a deceased Fellow. These amounts now stand in £334, 10*s.* 9*d.* East Indian Railway 3-per-cent. Debenture Stock.

	£	*s.*	*d.*		£	*s.*	*d.*
1921 Jan. 1. Balance of Fund	37	3	10	1921. Grant from Fund ...	12	0	0
1921. Dividends, East Indian Railway ...	10	0	9	1921. Dec. 31. Balance of Fund	35	4	7
	£47	4	7		£47	4	7

The Turnor Fund and the Horrocks Memorial Fund: In 1853 the Rev. Charles Turnor, M.A., bequeathed a sum of £500, which now stands in £464, 18*s.* East Indian Railway 3-per-cent. Debenture Stock. In 1876 the Society received a sum of £38, 15*s.*, the unexpended balance of a fund collected for the purpose of erecting a memorial in Westminster Abbey to Jeremiah Horrocks: to this the Society added the sum of £55, 15*s.*, and the whole now stands in £103, 6*s.* East Indian Railway 3-per-cent. Debenture Stock. The interest on these funds is to be used in the purchase of books for the Library.

	£	*s.*	*d.*		£	*s.*	*d.*
1921 Jan. 1. Balance of Fund	4	7	5	1921. Purchase of Books ...	24	9	1
1921. Dividends, East Indian Railway ...	17	1	0				
Due to Fund	3	0	8				
	£24	9	1		£24	9	1

The Harry Watson Fund: In 1920 Mrs. Watson presented to the Society the sum of £300 as a memorial to her late husband, Lieut.-Col. Harry James Watson, F.R.A.S., the interest on this sum to be used for the purchase of books for the Library, such books to be indicated by a special book-plate. This gift now stands invested in £542, 18*s.* 2*d.* India 3½-per-cent. stock.

	£	*s.*	*d.*		£	*s.*	*d.*
1920. Dividends, India 3½ per cent.	9	10	0	1921. Purchase of Books ...	10	0	0
1921. Dividends, ditto ...	19	0	0	1921 Dec. 31. Balance of Fund	18	10	0
	£28	10	0		£28	10	0

The Hannah Jackson (née Gwilt) Fund: In 1861 Mrs. Hannah Jackson (*née* Gwilt) gave £300 Consols, which now stands in £309, 18*s.* 6*d.* East Indian Railway 3-per-cent. Debenture Stock; the interest to be given in medals or other awards in accordance with the terms of the Trust.

	£	*s.*	*d.*		£	*s.*	*d.*
1921 Jan. 1. Balance of Fund	56	12	5	1921 Dec. 31. Balance of Fund	65	18	5
1921. Dividends, East Indian Railway ...	9	6	0				
	£65	18	5		£65	18	5

The Sir David Gill Bequest: The following is an extract from the Will of the late Sir David Gill, who died 1914 January 24:—

I direct my Trustees and Executors to pay to the Royal Astronomical Society of London (the receipt of the Secretary for the time being a full and efficient discharge) the sum of two hundred and fifty pounds to be employed by the Council of the said Society in aid of Astronomical Research, and I desire to declare that I make this bequest in grateful remembrance of a like sum paid out of the funds of the said Society in aid of my expedition to Ascension in the year one thousand eight hundred and seventy-seven, and I express a wish that the said sum be devoted in part or in whole to some expenditure of a like character to complete some great work, such as the computation of New Tables of the Satellites of Jupiter or other like undertaking of fundamental importance to Astronomy, but I expressly provide and declare that the same shall not be applied to Eclipse Expeditions, as these are now recognised as objects which are provided for by Government or other funds.

This sum was invested in £275, 16*s.* 0*d.* 5-per-cent. War Loan Registered Stock, which was sold in 1921 November to defray part of the cost of vol. lxiii. of the *Memoirs*, containing the theory of the four great Satellites of Jupiter.

Assets and Present Property of the Society, 1921 *January* 1.

	£ s. d.	£ s. d.
Balances, 1921 December 31:—		
In hand of Assistant Secretary on Petty Cash Account	8 19 8	
Cheque outstanding	3 3 0	
		12 2 8
Due on account of Subscriptions:—		
14 Contributions of 3 years' standing	88 4 0	
34 ,, 2 ,, ,, ...	142 16 0	
55 ,, 1 ,, ,, ...	115 10 0	
Other sums	1 10 0	
	348 0 0	
Less paid in advance	10 10 0	
		337 10 0
Due from Wheldon & Wesley for sales of Publications during the last quarter of 1921		21 14 7
Due for Publications sold		3 16 0
		375 3 3
Debit Balance at Bankers, 1921 Dec. 31	8 10 9	
Due to Assistant Secretary on account of Turnor and Horrocks Fund	18 5 4	
		26 16 1
		348 7 2

£1,250 Metropolitan 3-per-cent. Stock.

£2,000 Swansea Corporation 3½-per-cent. Stock.

£3,500 East Indian Railway 3-per-cent. Debenture Stock.

£3,500 London and North-Western Railway 3-per-cent. Debenture Stock.

£4,000 Midland Railway 2½-per-cent. Debenture Stock.

£1,000 Lancashire and Yorkshire Railway 3-per-cent. Consolidated Preference Stock.

£2,400 Gas Light and Coke Co. 3-per-cent. Debenture Stock.

£2,000 Commercial Gas Co. 3-per-cent. Debenture Stock.

£1,352, 12s. 6d. War Loan 5-per-cent. Inscribed Stock.

£542, 18s. 2d. India 3½-per-cent. Stock.

Astronomical and other Manuscripts, Books, Prints, Photographs, and Instruments.

Furniture, etc.

Stock of Publications and Photographs.

One Gold Medal.

Celestial Photographs.

The following have been added to the list of Celestial Photographs reproduced by the Society for sale to the Fellows :—

R.A.S. Ref. No.

310. 20 ft. Interferometer, Mount Wilson Observatory.
311. Jupiter, 1917 Nov. 16, J. H. Reynolds.
312. Jupiter, 1917 Dec. 21, J. H. Reynolds.
313. Jupiter, 1919 Feb. 13, J. H. Reynolds.
314. Nebula N.G.C. 151, 1920 Nov. 2, Helwân Observatory.
315. Nebula N.G.C. 1097, 1920 Nov. 15, Helwân Observatory.
316. Nebula N.G.C. 2835, 1920 Nov. 20, Helwân Observatory.
317. M. 81, Proper Motion in 1300 years, Van Maanen.

Publications of the Society.

During the past year vol. lxxxi. of the *Monthly Notices* has been published, also *Memoirs*, vol. lxiii.

Obituary.

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year:—

Fellows:—Herbert Francis Acocks.
William Barnett.
Thomas Lawrence Bennett.
Henry Lord Boulton.
Henry Bourget.
William R. Brooks.
George Bruford.
Ernest Carpmael.
Robert Bellamy Clifton.
Archibald Spencer Drummond.
Henry Tresawna Gerrans.
Alfred Newton Harris.
John Herschel.
George James Jacobs.
* George William Jones.
Rajah Jugga Row.
Edward Herbert Lees.
James Love.
Lord Moulton of Bank.
Charles A. Post.
William Edward Rolston.
William Shackleton.
John Spence.
Edmund Johnson Spitta.
Abraham Barsley Taylor.
Harry Samuel Williams.
Stephen M. Yeates.

Fellow and Associate:—Sherburne Wesley Burnham.

Associates:—Wilhelm Foerster.
Magnus Nyrén.

Herbert Francis Acocks, A.M.I.C.E., was born at Chester on 1861 October 9, his mother being a daughter of John Braithwaite, the well-known railway engineer. He was educated at Dulwich College, and after spending some time in Germany, France, and Switzerland entered his uncle's firm, Messrs. Braithwaite & Kirk, the world-known bridge and constructional engineers, at West Bromwich. Later he was successively in the drawing-offices of the London & South-Western Railway at Waterloo, the Great Western Railway at Paddington, and Messrs. Coode, Son & Matthews, the dock-harbour engineers. He returned eventually to the London & South-Western Railway as a special assistant to Mr. A. W. Szlumper, the chief engineer. There he spent the last few years of his life, being largely engaged upon the

* Died in 1918, but death not reported till 1921.

rebuilding of Waterloo Station. He possessed marked mathematical capacity which found an important field for its application in the high engineering calculations involved in structural designs.

In 1898 he made an extended visit to his brother in New Zealand.

He was a man of sterling qualities and attractive character, and of exceptionally wide culture and interests. An accomplished amateur musician, he composed several songs and pieces for the piano. He was also much interested in botany and other branches of science, was conversant with the French and German languages, and frequently spent his vacations in the Swiss mountains.

As an amateur astronomer he was widely read, and at one time was associated in the measurement of double stars with his friend the Rev. T. E. R. Phillips, the Coleman Equatorial and Observatory lent to the latter by the Society being erected in his garden at Ashtead. His measures were communicated to the Society.

He never married, but lived with his aunt, Miss H. F. Braithwaite, who predeceased him by about a year. He died on 1921 September 14.

He was elected a Fellow of the Society on 1913 March 14.

William Barnett was born on 1842 Aug. 9 at Belfast: he was the son of Mr. Richard Barnett of that city. The larger part of his life, however, was spent in the Argentine Republic, where he was one of the oldest British residents, having been in the Province of Santa Fé since the year 1863. During the 58 years of his life in the country of his adoption he saw many changes and developments, and was British Consul at Rosario from 1876 to 1879, where he had established the well-known firm of Barnett & Co., Ltd., Lloyds' and Royal Mail Agents, etc. He was also interested in land and cattle.

In addition to his business claims, he was directly or indirectly connected with many religious and charitable institutions. For several years he was a Vice-President of the South American Missionary Society, and was one of the founders of the Rosario City Mission and Orphanage. He was ever ready to assist the sick and needy, and during the cholera epidemic which visited the country some years ago he took an active part in combating the scourge. He was very greatly beloved and respected by all classes and will be greatly missed in Rosario and the neighbourhood.

In 1875 he married Emmie Catherine, daughter of the late Rev. G. C. Evans of Downham Rectory, Essex. They had no family. He and his wife paid many visits to England, and together travelled extensively in South America, Egypt, Palestine, India, and Ceylon.

As a hobby he took a very deep interest in astronomical matters, and set up in Rosario a refracting telescope (which he later fitted with a solar spectroscope) for the study of the Sun. With this apparatus he made a number of careful observations which he communicated to the Solar Section of the British Astronomical Association, and which were published in its *Memoirs*.

He died at Bournemouth on 1921 Aug. 8, a few weeks after arriving in England, and his widow, who had been a sharer in all his works and interests, followed him on Oct. 3.

He was elected a Fellow of the Society on 1911 Feb. 10.

HENRY BOURGET was born in 1864 at Clermont-Ferrand, where his father was Professor of the Faculty of Sciences and later Rector of the Academy of Aix. He himself showed marked ability, both literary and scientific, and after his university career joined the staff of the Toulouse Observatory, where he served for twelve years under M. Baillaud. During this time he carried out a number of important researches, and his thesis for the doctor's degree—"Sur une classe particulière de groupes hyperabéliens"—showed him to be a worthy pupil of Emile Picard. Mention must also be made of his publication, in conjunction with M. Baillaud, of the correspondence of Hermite with Stieltjes, and of the fact that Picard showed his appreciation of him by entrusting to him the proofs of Hermite's complete works.

At the Toulouse Observatory he took an active share in the work of that part of the *Astrographic Catalogue* assigned to the observatory, and also made use of the large reflector for photographic purposes with much success. He further threw himself energetically into the Eros campaign.

In 1907 he was called to the Directorship of the Observatory of Marseilles, an office which he filled with conspicuous success. In addition to the ordinary astronomical equipment of the observatory, he installed a seismograph. He also devoted much attention to time determinations, and organised the daily reception of the wireless time signals from the Eiffel Tower at the observatory and in the town of Marseilles. These matters of routine naturally made large demands on his time, but he was nevertheless able to carry out a number of important researches. Amongst these reference may be made to his investigation, in conjunction with MM. Charles Fabry and Buisson, of the internal movements of the Orion Nebula. He also collected in one volume the observations of nebulæ previously made at Marseilles, but scattered throughout various publications.

Realising the importance of getting observations published without delay, he consented to make Marseilles a centre of information concerning the Minor Planets, and, in conjunction with M. Louis Fabry, distributed telegrams and circulars relating to them. After the outbreak of the war he founded the *Journal des Observateurs*, to take the place of the *Astronomische Nachrichten*, the first number appearing on 1915 October 15.

He died on 1921 September 21.

He was elected a Fellow of the Society on 1903 January 9.

WILLIAM R. BROOKS, Professor of Astronomy at Hobart College, U.S.A., since 1900, was born at Maidstone, Kent, in 1844, but in 1857 went to America and settled with his family at Darien, N.Y. He early took a deep interest in astronomy, and at the age of fourteen made a telescope with his own hands with which he observed Donati's comet of 1858. In business he was employed at the Shepherd Ironworks in Buffalo, and there gained practical experience in mechanical work which helped him much in the construction of the instruments with which he afterwards carried on a large part of his observational work. On 1881 October 4 he discovered his first comet, and on moving to a farm at Phelps, N.Y., set up an observatory where he discovered 11 more. In 1888 he moved to Geneva, N.Y., and was appointed

to the charge of the Smith Observatory, and between that year and the end of 1912 added no fewer than 16 to his already long list of cometary discoveries. The record number of such discoveries is held by Pons with 28, but Brooks comes second with 27.

Among the more interesting of his comets the following may be specially mentioned:—

(1) Comet 1893 I., the tail of which showed on October 21 distortions such as had not previously been recorded of any comet, and which resembled the remarkable appearances exhibited by Morehouse's comet 1908 III.

(2) Comet 1889 V., his second periodical comet, which was observed to throw off separate fragments in a somewhat similar manner to Biela's comet of 1846 and the great comet of 1882. Two of these fragments survived for some time as miniatures of the main comet with nucleus and tail, while one of them before disappearing actually became brighter than its parent.

(3) Comet 1911 I., a comet which in the early autumn of that year became quite a conspicuous naked-eye object in the morning sky.

Brooks considered, however, that his greatest triumph was his detection on 1883 September 3 of Pons's comet of 1812 on the occasion of its first return.

His cometary discoveries naturally brought him many prizes, including medals from the Lick Observatory, the Astronomical Society of the Pacific, the International Jury at the St. Louis Exhibition, the Astronomical Society of Mexico, and the Lalande Medal awarded by the Paris Academy of Sciences.

He died on 1921 May 3.

He was elected a Fellow of the Society on 1888 January 13.

George Bruford was born on 1837 January 13 in Vauxhall Bridge Road, then a country lane. He was descended from a Somersetshire family of yeomen farmers, whose history he himself traced back to the sixteenth century. His father, a cabinet-maker, died in 1848, leaving a widow and five children in very poor circumstances. George, who was the eldest of the family, worked hard to help to support it. During most of his working life he was connected with two firms of jewellers, first with that now known as Catchpole & Williams, while in 1878 he became a partner in that of Carrington & Co. He retired from business in 1895, and found more leisure for the study of astronomy, to which he had been attracted since reading Dick's works in his youth.

He took two extended tours, in 1901 to Australia and South Africa, in 1904 to Trinidad; he has left an account of the first tour, which he undertook partly in order to study the Southern heavens, in a little work, *The Wandering Quartette.*

He successfully observed the total solar eclipse of 1905 from Burgos.

He died on 1921 February 5, at the age of 84, having retained his faculties to the end; his widow and two sons and a daughter survive him.

He was elected a Fellow of the Society on 1909 May 14.

Ernest Carpmael, seventh son of William Carpmael, C.E., of Lincoln's Inn, was born in 1844, and took his degree at Cambridge as 6th Wrangler in 1867. Two years later he was elected a Fellow of his College, St. John's. Shortly after this he was called to the Bar by the Middle Temple, and went to the Northern Circuit. He practised chiefly in patent cases, and in 1895 took silk.

He was much interested in astronomical and other scientific matters, and joined the Royal Geographical Society and the Royal Institution. The claims of his profession were such as to prevent him from taking up practical research work, but he always kept himself well abreast of the times in his knowledge of recent scientific progress.

He died on 1921 December 4.

He was elected a Fellow of the Society on 1873 February 14.

Robert Bellamy Clifton was born on 1836 March 13, and received his education at University College, London, and St. John's College, Cambridge, graduating as sixth Wrangler in the Tripos of 1859. He afterwards obtained a Fellowship at St. John's, but in 1860 went to Owens College, Manchester, as Professor of Natural Philosophy. In 1865 he was appointed Professor of Experimental Philosophy at Oxford, and held the post for 40 years. During this time he saw the erection of the Clarendon Laboratory, which was completed in 1872, and took the leading part in its equipment, much of the apparatus installed being of his own design and construction.

As a teacher he possessed in a marked degree the power of inspiring enthusiasm in his students, and spared no pains in the preparation of the experiments for illustrating his lectures. It has been said that during his time at the Laboratory there was but little done in the way of "research" in the sense in which the word is now generally used, but at any rate the students were all given a thorough grounding in experimental methods and were invariably taught to aim at the highest attainable accuracy in their work. Clifton also maintained a personal interest in his pupils after they left the university, and he frequently took much trouble in finding for them suitable posts.

Naturally he had sundry duties outside the university. From 1879 to 1886 he served on the Royal Commission on Accidents in Mines, was President of the Physical Society from 1882 to 1884, and for several years was on the Council of the Royal Society.

He was a man of a very lovable disposition. He had married in 1862 Miss Catherine Elizabeth Butler, and together they welcomed in a most hospitable manner students and others to their house.

Amongst other things he took an interest in the progress of Astronomy, though he does not appear to have done any original work in this field. He died on 1921 Feb. 21.

He was elected a Fellow of the Society on 1860 April 13.

Archibald Spencer Drummond, of the Chantry, Bisley, Stroud, Gloucestershire, was born on 1853 Oct. 9, and died on 1921 Feb. 6, aged 67. He was a son of the late Harvey Drummond, senior partner in Messrs. Drummond's Bank, was related to the Earl of Perth, and was

descended from the 4th Viscount Strathallan. He served in the Scots Guards for 28 years, and retired as a Major in 1899. He was A.D.C. to the Major-General commanding troops in China and the Straits Settlements, served in the Nile Expedition of 1884-85, took part in the action at Abu-Klea, and received the medal with two clasps and the bronze star. His knowledge of astronomy was of great help during the Expedition. He married in 1891 Helen Sherer Burns, daughter of the late J. W. Burns of Kilmahew, N.B., and a granddaughter of one of the founders of the Cunard Company. He had a son and a daughter; the former, Lieut. H. Gerald B. Drummond of the Scots Guards, being killed in action during the European War, while commanding Right Flank Company in France in 1918, aged 20. Major Drummond contributed articles on Astronomy to the Press, and was also much interested in other branches of science, being a Fellow of the Royal Geographical and Royal Zoological Societies. He was a staunch Unionist in politics, and a strong advocate of the Daylight Saving Scheme. He had a most generous, kindly, and just disposition, and took a keen interest in local charities and sports.

He was elected a Fellow of the Society on 1894 Nov. 9.

Henry Tresawna Gerrans was born at Plymouth in 1858. He was educated at Cheltenham and Bristol Grammar Schools, and going up to Christchurch, Oxford, in 1877 he entered upon a distinguished university career. He obtained a first class in Mathematical Moderations and the final school, won the Senior Mathematical Scholarship, and gained the reputation of being one of the best mathematicians Oxford had seen for some generations. He also obtained a second class in Natural Science, possessed a good knowledge of the Classics, and was an exceptionally able student of modern languages.

In 1882 he was elected a Fellow of Worcester College, and in 1895 he was made Proctor. As a member of the Hebdomadal Council he did most valuable work, serving on several of its committees, and was responsible for much of the legislation of the university. He was also one of the first members of the Finance Board, a curator of the University Chest, and a delegate of the Clarendon Press.

But it was probably in connection with matters relating to general education that he was best known outside the university. In 1887 he was appointed to the Secretaryship of the Local Examinations Delegacy, and he did a great deal in organising and extending its field of usefulness. He also served on the Royal Commission for Secondary Education, and on the Secondary Schools Examination Council.

In 1889 he married Miss A. Elizabeth English. He travelled a good deal and had many friends abroad, especially in America.

He died on 1921 June 20, and his loss to Oxford, to which he had so whole-heartedly devoted his great abilities, will long be keenly felt.

He was elected a Fellow of the Society on 1902 May 9.

Alfred Newton Harris was born on 1837 October 13, of an old Plymouth family: he was the only son of the late Thomas Gibbs Harris. He was educated locally.

In 1861 he married Margaretta, daughter of the late Capt. William Harper, by whom he had three sons and three daughters, all of whom survive him.

About thirty years ago he was a contributor to the columns of the *English Mechanic*, and was always ready to assist and encourage beginners. He also aroused a good deal of local interest in astronomy by lectures. Being of a practical and mechanical turn of mind, he gave his attention to the construction of reflecting telescopes, grinding and polishing the mirrors himself, for which purpose he made use of glass discs specially cast for him at Newcastle. Amongst his mirrors were an 8-inch Cassegrain and a 12-inch, mounted in the Newtonian form, while he also possessed a $3\frac{1}{2}$-inch equatorial refractor by Wray. He employed his 12-inch reflector in taking photographs of the moon. He was also an artist of ability.

He died on 1921 August 8, in his 84th year. During the previous ten years he had had several seizures, the final one being about ten days before his death. Despite his physical infirmities, however, he retained his keen interest in astronomy to the last, and only a few weeks before his death constructed a planisphere for one of his grandchildren.

He was elected a Fellow of the Society on 1890 February 14.

John Herschel, Col. R.E., the youngest son of Sir J. F. W. Herschel, was born at the Cape in 1837, and inherited much of the ability of his father and grandfather. He was educated at Clapham Grammar School and Addiscombe.

In 1856 he joined the Bengal Engineers, but did not land in India till after the Mutiny. Soon after his arrival he was appointed to serve on the great Trigonometrical Survey, and when he retired in 1886 he held the office of Deputy-Superintendent. In 1881–2 he carried out a series of pendulum observations at Kew and Washington, thus connecting up the Indian stations with the principal groups of stations in other parts of the world. Various papers dealing with gravity determinations were published by him, and a paper on "Gravimeters, with a special reference to Broun's Torsion Gravimeter" (*Proc. R.S.*, 32, 507).

Amongst his astronomical observations may be mentioned his drawings of the Nebula surrounding η Argus, his observations of the spectra of southern nebulæ, and his spectroscopic observations of the solar eclipses of 1868 and 1871. At the former eclipse he found the light of the prominences to be almost entirely concentrated in three bright lines in the red, orange, and blue, and suggested as probable their identity with the C, D, and F Fraunhofer lines.

In *M.N.*, 31, 239, there is a paper by him on a contrivance for the automatic measurement of time in observing star or other transits, his idea being that a wire should be made to accompany the star's image by mechanical means controlled by hand, and make electrical contact at a definite point or points during its passage. Sir George Airy, Astronomer Royal, approved the idea as ingenious, but thought that the practical difficulties might be too great for it to be successfully applied. It is

interesting to note how Herschel anticipated the method now actually employed at Greenwich and elsewhere, in which a travelling wire makes a series of contacts in transit observations.

In 1905 he edited for the *Phil. Trans.* (**205**, 399) two Memoirs by Sir William Herschel on the brightness of the stars, which had not previously been published.

Herschel was a Fellow of the Royal Society, a member of the Senate of Calcutta University, and in 1884 served on the Council of this Society.

He married in 1867 Mary Cornwallis, daughter of the Rev. F. Lipscomb, rector of Welbury, Yorkshire, and widow of David Power, Q.C. She died about nine years later. His own death occurred on 1921 May 31.

He was elected a Fellow of the Society on 1872 February 9.

Edward Herbert Lees was born at Bideford in Devon, England, on 1856 March 8, and died at "Fairhaven," Mallacoota, East Gippsland, Victoria, on 1921 June 30.

Going to Australia about forty years ago, he was entrusted by the Survey Department at Adelaide for about three years and a half with the charge of a trigonometrical party, during which time he triangulated 20,000 square miles between the 26th and 30th parallels of south latitude and the 134th and 137th meridians of east longitude, and furnished the usual trigonometrical and topographical plans of the country, showing natural features with descriptions of timber and vegetation. He also made astronomical and magnetic observations.

Coming to Victoria in 1885, he was employed in connection with the Water Supply Department in carrying out extensive trial surveys for storage and channel works in the Wimmera and Loddon River districts, the permanent and descriptive surveys including borings for an important work at Laanecoorie. In 1888 he was appointed under the Land Department as Land Surveyor and Engineer in the county of Croajingolong, Eastern Gippsland. He resided for a while at Orbost, but in a few years removed to Mallacoota, where he built a beautiful home on that picturesque lake, and where he resided until his death. During these 33 years he was engaged on geodetic and general survey work over this vast area from the Murray River to the Southern Ocean.

Mr. Lees was highly esteemed both in South Australia and Victoria as a most capable and reliable officer, devoted to his profession, and thoroughly competent as a Land and Engineering Surveyor. He took an active interest in scientific studies, was held in high esteem for his genial and kindly nature, and was ever ready to give practical help and advice to those requiring it. He was a member of the Field Naturalists' Club of Victoria, the Victorian Institute of Surveyors, the Royal Yacht Club, and the Yorick Club of Melbourne.

In 1884 he married Florence, the eldest daughter of the late William Peebles of Jolimont, Victoria. There is no family living, but the widow survives.

He was elected a Fellow of the Society on 1892 Jan 8.

JOHN FLETCHER MOULTON, afterwards Lord Moulton of Bank, was born in 1844, his father being the Rev. James Egan Moulton, at one time President of the Wesleyan Conference. He was educated at a school at New Kingswood, near Bath, and proceeding to St. John's College, Cambridge, became Senior Wrangler and Smith's Prizeman. He also gained a Fellowship at Christ's College but soon resigned it, and in 1874 entered on the legal profession. On being called to the Bar his wide scientific knowledge served him in good stead, and he became unrivalled as an expert in patent and kindred cases, and obtained a large practice. He was a keen student of economics, with strong views on taxation and land values. In 1885 he entered the House of Commons as Member for Clapham, but lost his seat at the time of the Liberal split. Subsequently he sat as member for S. Hackney, and later for the Launceston Division of Cornwall; but after 1906 he retired from the House of Commons and became a Lord Justice of Appeal. Six years later he was made Lord of Appeal and a member of the Judicial Committee of the Privy Council. Besides being an able mathematician, Lord Moulton was a classical scholar and possessed a wide knowledge of modern languages. In science he specialised in physics and chemistry, and was elected a Fellow of the Royal Society. At the outbreak of the war he found a sphere of special usefulness at the Ministry of Munitions, and he was appointed Director General of Explosive Supplies for all our forces. Unknown to the public generally, his work in this connection, and also in the manufacture of poison gas after the Germans had introduced this method of warfare, proved of inestimable value and contributed in large measure to the ultimate victory of the Allies. At the conclusion of the war he devoted his energies largely to the improvement of educational methods, especially in regard to the teaching of science. He also served at various times on commissions and received numerous honours. He was made K.C.B. in 1915 and G.B.E. in 1917.

Though he did not do any special work in the field of astronomy, he was much interested in the progress of the science and in all that concerned its welfare. At the Special General Meeting of the Society held on 1881 April 9, to consider a motion relating to the endowment of research by the Government, he seconded the amendment, proposed by Professor H. J. S. Smith, and carried by a large majority, that there was no sufficient reason why the Society in its corporate capacity should express any opinion on the subject.

In 1914 he presided over the meetings held in Edinburgh to celebrate the Tercentenary of Napier's discovery of logarithms.

Lord Moulton was twice married. His first wife, by whom he had one son, was Mrs. Thomson, widow of Mr. R. W. Thomson who was one of the first to take out a patent for the pneumatic tyre. Some years after her death he married Miss Mary Davis, the daughter of an American gentleman.

He was elected a Fellow of the Society on 1874 Dec. 11.

CHARLES ALFRED POST, son of the late Joel Browne Post and Abby Mauran Church, was born in New York City, 1844 January 6, and entered Columbia College in his fifteenth year. In 1861 he enlisted in

the 22nd N.Y. Volunteer Regiment as a private, and during the year of his service was promoted to corporal, second sergeant, first sergeant, colour-sergeant, sergeant-major, and second lieutenant of Company C in the field. At the expiration of his term of enlistment he entered the Navy, and on the U.S.S. *Florida* took part in the blockade off Wilmington, N.C.

On the close of his service he entered the Columbia Law School, graduating with the degree of LL.B., and pursued the practice of law in New York City, having the care and management of the family estate.

Later in life he took up the study of astronomy as a recreation with marked success, and at his country place in Bayport, Long Island, built one of the best equipped amateur observatories in the country. He was one of the astronomers attached to the Eclipse Expedition of the Naval Observatory to Brownsville, Georgia, in 1900, and the same year received the honorary degree of Master of Arts from Columbia College in recognition of his astronomical work.

Post was a member of the Naval Order of the United States; a Fellow of the American Association for the Advancement of Science; a Fellow of the New York Academy of Sciences; a Fellow of the Astronomical and Astrophysical Society of America; a member of the Astronomical Society of the Pacific. He also belonged to the Delta Phi Fraternity, the Union Club, and many other social and literary organisations. He died in New York on 1921 April 26.

He is survived by his wife, Marie Caroline, *née* de Trobriand, daughter of General Comte de Trobriand, and two daughters, Mrs Duncan Candler and Mrs Goelet Gallatin.

He was elected a Fellow of the Society on 1895 Feb. 8.

William Edward Rolston was born at Birmingham in 1876 on October 18, the second son of William Woodman Rolston, a maker of scientific instruments. He was educated at the Birmingham Municipal Technical School, and after a course as Teacher in Training at the Royal College of Science, where he was also a demonstrator in the courses on Astrophysics, and did some work as computer in the Solar Physics Observatory for a short time, he went in 1898 as science master to Cleobury Mortimer, and in 1899 to Cheadle Hulme, near Stockport.

In 1901 he returned to the Solar Physics Observatory as computer, and on the transference of the Observatory to Cambridge in 1913 he was appointed on the staff as first junior observer. His earliest work at South Kensington related to the observation of the ultra-violet extension of the spectra of stars selected as representatives of the various stages in Sir Norman Lockyer's classification of stars in two branches of ascending and descending temperatures. The spectra of pairs of stars were for this purpose photographed with a special prismatic camera, provided with a calcite prism and a quartz lens. The selected pair of stars, in general widely separated in the sky, were to be photographed when they were approximately at the same altitude. Isochromatic plates were used, for it was desired to make comparisons of the intensities at the red end of the spectra as well as the ultra-violet, effort being directed to obtain each pair of spectra of equal intensity in the

region between H_β and $H\gamma$. It was a troublesome bit of observational work successfully carried out by Mr. Rolston in collaboration with Mr. Goodson. The results were given in Sir Norman Lockyer's paper entitled "Further Researches on the Temperature Classification of Stars," communicated to the Royal Society and published in the *Proceedings*, **73**, 227 (1904).

Rolston took part in other researches carried out at South Kensington, such as wave-length reductions of enhanced lines of various metals (1906) and the observation of widened lines in sun-spot spectra. Another piece of work in which he was closely concerned was that relating to the orientation of stone circles and temples in various countries, a subject in which Sir Norman Lockyer was much interested, in the hope that thereby the date of inauguration of such structures might be determined. The results were communicated by Sir N. Lockyer in the years 1906–7, some in a series of papers to the Royal Society and others in his book on *Stonehenge and other British Stone Monuments* (1906). In all of these Rolston is referred to as having undertaken the reductions for the orientations.

He was responsible too for the compilation of a memoir on the "Phenomena of New Stars," summarising in a very serviceable way a great deal of scattered material. It was published under the auspices of the Solar Physics Committee in 1914. For several years he contributed the notes for the astronomical column in *Nature*.

After the transference of the Observatory to Cambridge in 1913, his first work was concerned with comparisons of stellar spectra, and he devoted considerable time to investigations with the new spectrograph attached to the Huggins 15-inch equatorial. He had successfully got this instrument into excellent working order when the war broke out. He then went into training with the Officers' Training Corps at Cambridge, and in 1915 he got a Commission in the Buffs (5th Weald of Kent). He went to France in February 1918, attached to one of the Sound Ranging Sections in the 4th Field Service Battalion. After the Armistice he went with the Army of Occupation to Cologne. There he was attached to the Military Governor's Staff and became the founder and managing editor of the *Cologne Post*, a remarkable daily newspaper printed in English by German compositors, and much appreciated by the British troops in Cologne. Rolston threw himself with unsparing zeal into the labours of his task; and when British Forces went into Upper Silesia in the summer of 1921, an Upper Silesian edition of the *Cologne Post* was issued, which aimed at supplying news at Oppeln forty-eight hours ahead of that in the papers received from home. It seems clear that he must have overtaxed his strength, for he died after a few hours' illness on 1921 August 9, in the midst of his work, and on the very day that he was expecting his wife and children to join him at Cologne. He was buried at the Südfriedhof with military honours—a man of earnest character and of public-spirited interests. His early death in the prime of life is a matter of deep regret to his colleagues and many friends.

Captain Rolston was elected a Fellow of the Society in 1904 April 8.

H. F. N.

William Shackleton was born in 1871 at Keighley, and was educated at the Keighley Trade and Grammar School and the Royal College of Science, South Kensington, where he obtained his Associateship in 1891. He then became an assistant to Sir Norman Lockyer at the Solar Physics Observatory at South Kensington, his practical skill and enthusiasm as an observer during the next ten years contributing largely towards the successful pioneer work of the observatory.

During this period he took part in two eclipse expeditions organised by Lockyer, the first in Brazil with Mr. A. Taylor in 1893, and the second in Novaya Zembla in 1896 with Dr. E. J. Stone. Successful photographs of chromospheric spectra were obtained on both occasions, and at Novaya Zembla the series included some excellent photographs of the corona and, for the first time, a photograph of the complete "flash" spectrum, with perfect definition. This fine result was only made possible by Mr. Shackleton's skill and resource under great difficulties. The grounding of Sir George Baden Powell's yacht *Otaria*, which had conveyed the observers to the eclipse station, and bad weather conditions during the period before the eclipse, were not encouraging; but by taking advantage of every interval of clear sky, Mr. Shackleton completed his preparations in time to achieve a well-earned success.

During his stay in Brazil in 1893 he contracted malaria, recurrence of which affected his general health considerably for some years. In 1900 he was selected as physicist to go with Scott on his first Antarctic expedition, but after organising the instrumental equipment necessary for the observations contemplated, he was finally left behind on medical disqualification.

For some years he assisted Dr. A. A. Common in his observatory work, and in work connected with the design and manufacture of gun-sights and range-finders.

After Dr. Common's death in 1903, Mr. Shackleton was again in the Royal College of Science, acting for a short time as assistant in the Physics Department. Illness prevented his going to Spain in 1905 to observe the solar eclipse, for which he had designed a combined coronagraph and prismatic camera of 40 feet focal length, which was constructed and taken with the expedition. On this occasion, however, no observations were possible owing to bad weather conditions.

Later in this year he was appointed Inspector of Scientific Supplies at the India Stores Depôt, which post he retained during the remainder of his life. He gave himself whole-heartedly to the work of this Department, for which he was so well equipped by his extensive and expert practical knowledge of the design, construction, and performance of scientific instruments generally.

Various modifications and improvements in design and manufacture were due to suggestions made by him, and he introduced several improved methods of testing optical instruments. His careful work in supervision of details of design of the instruments required in India, and in testing them to ensure that all instruments sent out were satisfactory in performance for the particular purpose required, was much appreciated by scientific workers in that country.

In 1913 Mr. Shackleton became an active member of the Optical

Society, of which he was secretary from 1916 to 1920, when he was elected a vice-president. During these years the growth of the Society, both as regards membership and scope, was due in no small measure to his persistent efforts to bring men of science and makers of optical instruments into close association with each other. In his earlier years he was a keen athlete, but though his health in late years had not been satisfactory, his spirit of enthusiasm for his work remained undaunted, and the end, which came on 1921 June 26, was unexpected. He leaves a widow and one daughter.

He was elected a Fellow of the Society on 1893 December 8.

D. B.

The Rev. John Spence was born in Shetland, Scotland, some sixty years ago. He began life as a fisher lad, later on going to sea, and sailing further north—to Greenland—in the whale-fishing industry.

Mr. Spence subsequently left the sea and by dint of hard work became seamen's missionary at Fowey, Cornwall, afterwards entering the ministry and holding charges in Arbroath, Lerwick, Edinburgh, and London, at the time of his death being minister of St. Modan's Church, Falkirk, Scotland.

Navigation introduced Mr. Spence to the study of astronomy, which held its fascination over him throughout his life. He made a feature of simple astronomical lectures illustrated with lantern slides, and these lectures he was always delighted to give in aid of any charity brought to his notice. Mr. Spence also wrote on the subject, the best known of his works being probably *Christ in Astronomy*.

He had the gift of oratory in no small degree. His personality was magnetic and very kindly, and his sudden death on 1921 February 13 from angina pectoris—a few months after the death of his beloved wife—came as a shock to his many friends and admirers, who not only felt that they themselves had indeed lost a friend, but that the world was the poorer for the loss of one whose influence was always for good, and all that was best and uplifting.

He was elected a Fellow of the Society on 1897 April 9.

In Edmund Johnson Spitta, M.R.C.S., L.R.C.P.Lond., the Society loses a Fellow devoted to its service, who was on the Council almost continuously from 1889 to 1908, was a Vice-President 1903–5, and was a constant attendant at the meetings until the war made the journey from Hove impracticable. For not only was Hove put into complete darkness at night, but Dr. Spitta undertook the charge of a first-aid station in case of air raids. There can be little doubt that the severity of the consequent exposure (for whenever there was an alarm he promptly took his place, at any hour of the night, in the chilly and sometimes icy room) shortened his life. He had first one severe illness and then another, and though he seemed to recover something of his old cheeriness at times, he collapsed rather suddenly and died on 1921 January 21. Within the year one of his two daughters and then his grief-stricken wife followed him, death thus dealing a triple blow at a united and happy family. His only son and one daughter survive.

He was born at Clapham in 1853, a son of the late Dr. Robert John Spitta who was in practice there. He was educated at the Clapham Grammar School (under the successor of the Rev. Charles Pritchard, who later became Professor of Astronomy at Oxford), and entered St. George's Hospital in 1870, completing his studies at St. Thomas's and at Westminster, settled down as his father's partner in 1874, and ultimately took over the practice, which he pursued actively until 1904, when he retired to Hove.

Astromony was but one among his many enthusiasms; but he worked really hard at the phenomena of Jupiter's satellites (1884–1892, see various papers in the *Monthly Notices*). He made photometric determinations of their albedos, using for the purpose a neutral-tinted wedge such as had been adopted by Professor Pritchard for use on the stars. The problem of determining the scale value of such a wedge is beset, like most photometric problems, with difficulties; and there is no doubt that Spitta's hours of work and bewilderment were rewarded by the discovery of a systematic error (from internal reflections in the nicol prism used by more than one investigator) which had previously escaped attention and had falsified published results, though complete admission of these important consequences was not at the time forthcoming.

But the microscope and camera gradually drew him away from the telescope. His use of the microscope was miscellaneous. I remember him explaining the need for stropping a razor—the edge rusts slightly and the strop removes the rust: but I never met anyone else who had examined a razor edge in this way. He published, with Dr. Slater as colleague, an *Atlas of Bacteriology* in 1898, and a larger work in 1899. His son, Dr. Harold Spitta, who shared his enthusiasm and work in this direction, has risen to eminence as a bacteriologist. The father, after retiring from practice in 1904, wrote a big book of 500 pages on *Microscopy* (1907, John Murray) which has become the standard work on the subject and has already passed through three editions. "He was thoroughly entitled to enjoy his retired life," writes a close friend of his, "by the usual method of haunting clubs and playing golf: but he worked with untiring energy at microscopy, which was all the more remarkable because he was handicapped (and well knew it) by his non-mathematical mind, which hindered his progress over and over again. . . . Personally, my unbusiness-like self will always feel deeply indebted to him."

As President of the Quekett Microscopical Club he rescued the club from a threatened decadence and left it flourishing.

His great energy also found vent in public lecturing; and (especially during the war) he filled to overflowing many large lecture-halls on behalf of various charities. He also made a simple and effective suggestion (in connection with war work) for the construction of a good screw and for a process by which the successive stages of manufacture could be photographed for inspection. This valuable suggestion, after being scornfully rejected by official stupidity, was afterwards found to have been quietly adopted, with results of great value to the country.

Those who attend meetings of the Society to-day can perhaps scarcely realise the time when there was no lantern to aid the presentation of papers. The installation of the lantern was the work of Dr. Spitta,

and for many years he was regularly nominated by the Council as a "Lantern Committee" of one, to care for and improve it as occasion arose. He naturally occupied the front corner-seat next the lantern; and since he was kept away from the meetings by his war duties, that place has been filled for him by one of his old friends, in the hope that he would some day return to claim it. But the hope was vain.

H. H. T.

Abraham Barsley Taylor was born in Lincolnshire in 1856. He had little or no school education, as he began work at the early age of 9 years. Despite this great disadvantage he had a successful business career as a boot manufacturer, and was able in time to retire and follow up his astronomical interests. He had been attracted to the science when quite young, and later became a member of the Liverpool Astronomical Society. He died on 1921 June 29.

He was elected a Fellow of the Society on 1910 January 14.

Harry Samuel Williams, son of C. J. B. Williams, M.D., F.R.S., was born on 1840 March 4, and died on 1921 July 12. A scholar of St. John's College, Cambridge, he graduated in 1862 as 22nd Wrangler, and during part of his time at Cambridge he resided at the Observatory with Professor Challis.

Later he practised as a Solicitor in Bedford Row till 1882, when he retired and devoted himself to philanthropic work. He resided at Swansea for over thirty years, where he took part in many activities for the benefit of the poor, amongst other things building and maintaining at his own expense a school and mission room. He also worked zealously with the Young Men's Christian Association.

He married Grace Emily, daughter of George Watkins, Surgeon, of Guy House, Chepstow.

He was elected a Fellow of the Society on 1865 December 8.

Sherburne Wesley Burnham was born at Thetford, Vermont, U.S.A., on 1838 December 12. He was educated locally, and early took up the occupation of a shorthand reporter. About 1859 he was employed in New York, but during the Civil War he followed his occupation with the federal army at New Orleans. It was during this time that his attention was drawn to astronomy by the chance purchase of Burritt's *Geography of the Heavens*. The charts in this book induced him to study the heavens for himself, and soon he became an ardent amateur astronomer. His keenness for observing remained with him all his life, yet, except for four years (1888–1892) when he was officially attached to the Lick Observatory, he continued to work at his original profession. In 1892 he became Clerk to the U.S. Circuit Court in Chicago, and held this honourable position for a number of years. It was only when he was approaching his seventieth year that he retired from business.

Burnham purchased his first small telescope and exchanged it for his second when still at New Orleans, and for some time he appears to have regularly exchanged his telescope for another slightly better.

After the Civil War he settled down in Chicago quite near to the Dearborn Observatory, in which there had recently been installed by the firm of Alvan Clark & Sons an 18½-inch telescope—then the largest in the world. Probably the proximity of this great instrument inspired Burnham to get a better telescope for himself, and led to the purchase of his 6-inch telescope. Of the events which led to this purchase Burnham himself has told us in the Introduction to vol. i. of the *Publications of the Yerkes Observatory.*

"Some years later (about 1865) I obtained a 3¾-inch telescope, with an English object-glass, mounted equatorially by Fitz on a portable stand. This was just good enough to be of some use, and poor enough, so far as optical power was concerned, to make something better more desirable than ever. In 1869 I accidentally met Mr. Alvan G. Clark in Chicago . . . and made some inquiries of him about a small equatorial. This interview resulted in my ordering from the celebrated firm of Alvan Clark & Sons an equatorial of 6 inches aperture. I told them what I wanted and what I wanted it for. Every detail was left entirely to their judgment, stipulating only that its definition should be as perfect as they could make it, and that it should do on double stars all that it was possible for any instrument of that aperture to do. In due course of time this instrument was delivered, and was set up in an observatory prepared for it in the meantime. My attention, for some reason or other which I am unable to explain, had been almost exclusively directed to double stars, previous to this, while using the smaller telescope referred to."

Perhaps the reason why Burnham decided to devote his energies to double stars is to be found in the fact that one of the few astronomical books he possessed at this time was Rev. T. W. Webb's *Celestial Objects for Common Telescopes.* With his new telescope he began active operations, and soon both he and the telescope had become famous. It is familiar to every astronomer how he opened a new epoch in the discovery and observation of double stars. Following pioneer work by the Herschels the northern sky had twice been systematically surveyed for double stars: firstly, by W. Struve with the 9-inch Fraunhofer telescope at Dorpat 1824–27, and, secondly, by O. Struve with the 15-inch refractor at Pulkovo 1841–43. For nearly thirty years it was felt that all the double stars which could be revealed with existing telescopes had been discovered, and that all that remained in this branch of astronomy was to measure and remeasure them. In 1870 Burnham with only a 6-inch telescope began to discover new ones. His first catalogue, containing 81 new double stars, discovered in the years 1870–72, was published in the *Monthly Notices* for 1873. In congratulating him on his work Rev. T. W. Webb, himself a distinguished observer, probably voiced the opinion of all astronomers when he warned Burnham that his discoveries could not continue for very long for want of material. But still the discoveries went on, and list after list of new double stars appeared. It was some time before the full significance of Burnham's work was realised. The fact was that the Struves had detected the easy and fairly easy double stars, while Burnham was finding difficult and very difficult ones. The difficulty in detecting and ob-

serving double stars depends not only on their separation, but also on the brightness of the components. A considerable number of the new double stars which Burnham discovered can be roughly divided into two classes: (1) very close pairs (separation under 1″) in which the components are not too unequal and fairly bright; (2) wider pairs up to 10″ or more in which the brighter star is at least as bright as the seventh magnitude, and the companion so faint as to be almost invisible. In some extraordinarily difficult stars the components are markedly unequal and still separated by only 1″. The double stars discovered before Burnham's time were for the most part fairly easy objects with the telescopes then in use, and were discovered by what might be described as routine methods carefully and systematically applied. But most of Burnham's new double stars were discovered by minute examination of the star discs. He had a remarkable acuteness of vision and an eye wonderfully free from defects, while his telescope was practically perfect. If a star disc or the diffraction rings showed the slightest irregularity, he was not satisfied and returned to the star again and again till he was certain whether it was single or double.

Burnham's telescope had at first no driving clock and no micrometer. However, he contrived to turn the telescope by a weight attached to a cord wound round the polar axis. In this way he was able to make fairly accurate observations in position angle, but only estimates of the distances. The lack of measures by Burnham himself was supplied by his friend Baron Dembowski, the most accurate observer of that time, who devoted a great deal of his time to measuring the new double stars. Burnham has told us that the "kindly criticism and genial enthusiasm of Dembowski were always an inspiration to him"; but from the life Burnham led he does not appear to have required much inspiration from others. During the day he was occupied at his profession, but when the night was fine he worked till daylight drove him to bed. His work soon brought him into friendly personal relations with astronomers in Europe as well as in his own country. The finest telescopes in the country were placed at his disposal or pressed into his service. The life he led at this time may be indicated by a few short extracts from the introduction to his fifth catalogue published in the *Monthly Notices* for 1874 November.

"Unlike the four preceding catalogues to which my 6-inch refractor has alone contributed, the double stars contained in this have been found with apertures varying from 6 to 26 inches. . . . Passing through Washington . . . I had the pleasure of using the magnificent 26-inch recently erected. I had only one good night, and the 14 double stars in the following pages were all observed on that occasion. The time was principally spent in examining prominent stars, or familiar localities, in order to lose no time in determining places by reading circles, etc. . . . Before his departure for China on the Transit of Venus expedition, Prof. C. A. Young kindly placed the 9.4-inch refractor of the Dartmouth College Observatory at my disposal during a contemplated stay of a few weeks not far from that place . . . The double stars found with the 18·5-inch refractor of the Dearborn Observatory have been incidentally picked up at occasional visits."

Burnham continued to observe double stars on all possible occasions throughout his life. Besides the instruments already mentioned, he observed with the 15-inch telescope of Washburn Observatory, the 16-inch of the Warner Observatory, the 12-inch and 36-inch of the Lick Observatory, and, finally, the 40-inch of the Yerkes Observatory. In 1888 he accepted an official appointment at the Lick Observatory, but after four years he returned to Chicago. In his earlier years he had spent most of his time discovering double stars, but gradually he devoted a larger and larger portion of his time to measuring previously known but important or neglected stars. In all he discovered some 1340 new double stars. Of these 451 were discovered with the 6-inch telescope, 413 with the 18½-inch Dearborn telescope, and 198 with the 36-inch Lick Observatory telescope. Although the discoveries made with the larger telescopes include, on the whole, more difficult objects, some double stars discovered with the 6-inch are very difficult with any aperture. The binaries $\beta 80$, $\beta 151$, $\beta 359$, with periods well under 30 years and semi-major axes of less than $0''{\cdot}75$, were discovered with the 6-inch. A much more difficult star $\beta 552$, the components of which are of the 7th and 10th magnitudes and are separated by less than half a second, was discovered with the 18½-inch Dearborn telescope, but in 1874 it had been suspected with the 6-inch telescope, and the position angle estimated at that time has proved to be substantially correct.

In his early work Burnham was handicapped by want of astronomical books. The information about known double stars was scattered through many works, some of them scarce and not easily accessible. With great zeal he set himself the laborious task of compiling a manuscript catalogue of all observations of double stars, borrowing books and visiting libraries as he found opportunity. In this way he collected together practically all published information relating to double stars within 121° of the pole. The catalogue was kept up to date with new observations, and went through three manuscript editions before it was finally published by the Carnegie Institute of Washington in two magnificent volumes, *A General Catalogue of Double Stars.* These volumes form the standard reference work, and give references to all observations published before 1906. The mere collecting of the material for these volumes was an enormous piece of work. It was not originally done with a view to publication, but when publication was assured Burnham spared no pains to make the catalogue as complete and perfect as possible. He devoted five years of his observing time to one work, *i.e.* two consecutive nights each week with the 40-inch telescope, making nearly 10,000 measures. Much time was spent in the rather uninteresting work of searching for double stars which had been discovered by others but insufficiently recorded. The value of Burnham's work is greatly enhanced by the fact that he observed nearly all known double stars which had been neglected. Without Burnham's measures our knowledge of a great number of double stars would be much more defective than it is.

When the *General Catalogue* was finished Burnham was 68 years of age. He might have been expected to retire from active work,

but such appears to have been far from his thoughts. In the formation of the catalogue he seems to have been struck with the frequent discordance between the proper motions of stars deduced from meridian observations and the proper motions relative to faint stars in the neighbourhood. He considered the difference due to errors in the meridian work, and not to the proper motion of the faint stars. To test this he made about 9500 measures with the 40-inch telescope between 1907 and 1912. These observations were published by the Carnegie Institution in a volume, *Measures of Proper Motion Stars*. His final observations made in 1912 and early in 1913 were published in *A.J.*, 738.

It is impossible in the space at our disposal fully to describe Burnham's work. With no astronomical education he quickly grasped the essentials of double-star work. By pushing the resolving power of the telescope to its extreme limit he discovered many rapidly revolving systems. With only one or two exceptions, the double stars discovered before his time have periods over a century, while for the great majority centuries must elapse before relative motion will be observed. Burnham's discoveries include many close bright pairs, and amongst these, especially when the proper motion is large, rapid orbital motion may be expected. Consequently the proportion of Burnham stars amongst those for which orbits can be computed is large. This proportion will increase in the near future, though ultimately the continuous work done more recently with the 36-inch refractor should produce a large number of systems of short period.

We have mentioned something of the enormous amount of work Burnham accomplished, and of its value in filling gaps left by other observers. But our chief reason for indebtedness to him is the accuracy of his work. The accuracy of the work of W. Struve is well known, and Burnham has said of Dembowski that he made no mistakes. Burnham too made no mistakes. But the true value of this tribute to his work can only be reckoned along with the extremely difficult nature of many of the observations which he made. When he stated that a star was single it was single within the resolving power of his telescope, and when he indicated a direction of elongation that direction was never many degrees in error. In their attempts to measure very close double stars many observers make spurious observations. But such are not to be found amongst Burnham's measures. A single observation by Burnham is an unfailing comfort to the orbit computer when dealing with a close double star, and may be relied upon against any contrary evidence of his contemporaries.

He was essentially an amateur, although his work ranks with the greatest professional astronomers in any branch of the science. The work was undoubtedly heavy, and he himself realised it when in 1899 he wrote in the Introduction to the *General Catalogue* of his own stars, "With the exception of the four years 1888–1892, all this astronomical work, with the telescope and otherwise, has been done when eight or more hours of at least six days in the week were more or less occupied with other and very different affairs of life." Yet he continued to observe as long as he had physical strength, no matter how

much it involved. For 17 years, 1895–1912, he stayed at Chicago, and regularly went each week-end to observe with the 40-inch at the Yerkes Observatory through two consecutive nights, although each visit involved a journey of 160 miles, with a three-mile walk frequently through snow to the observatory. Can any similar record of work be found anywhere?

Burnham was the founder of modern double-star astronomy. His influence has been world-wide, and in his own country the work which he initiated is being nobly pursued. He was sincere and thorough in all his work, and had faith in his own observations and in his own opinions. Always unwilling to draw conclusions from insufficient data, he never believed in unseen disturbing bodies to explain discordant observations. He avoided everything sensational, and for half a century consistently adhered to the subject he had chosen and refused to leave it for more modern fields of research.

Burnham was well known to a large number of astronomers, and many have told of the cordiality with which he welcomed them to Chicago. Foreign astronomers passing across America often made a point of calling upon him to enjoy his society for a few hours. Although he made great contributions to science, he was broad-minded and had many interests in life. He was a great lover of Dickens, and often spoke of visiting London with a view to searching out the places mentioned in the novels. By his friends he is remembered as one of the best of mankind. One of them has written, "Simple and sincere, loving the truth and hating all pretence of sham, given to caustic speech but ever showing a kindly heart; a tireless worker and full of the joy of living, he was a rare comrade whose friendship made life a little better worth living."

His work was honoured at home and abroad. He was given honorary degrees by Yale University and the North-Western University. In 1894 he was awarded the Gold Medal of our Society, and ten years later the Lalande Prize of the Paris Academy of Sciences.

Burnham married in 1868, and is survived by a widow and six children, three sons and three daughters, as well as a number of grandchildren.

He died on 1921 March 11.

He was elected a Fellow on 1874 November 13, and an Associate on 1898 December 9. J. J.

Wilhelm Foerster was born on 1832 December 16 at Seydel, Silesia, being the second son of Friedrich Foerster, a cloth merchant. After early studies at Breslau he entered Berlin University in 1850. Humboldt's and Littrow's works had kindled an interest in astronomy, which he studied under Encke, and subsequently under Argelander at Bonn. In 1855 he became second assistant at Berlin Observatory, being made first assistant in 1860, on Bruhns's departure to Leipzig. He was appointed Director in 1865 on Encke's retirement. He had already been designated supernumerary Professor in 1863, in recognition of his work on the history of astronomy. In 1866 Auwers was elected to the Berlin Academy, and an intimacy between him and Foerster

began that continued for forty years: in the same year they were both elected Associates of the R.A.S.

Foerster's early work at Berlin was largely concerned with the minor planets. He also devoted time and energy to popularising astronomy both by writing and lecturing. When the Astronomische Gesellschaft was founded in 1863, he and Schönfeld were the first secretaries, and edited its *Vierteljahrschrift*. He had also charge of the *Berliner Jahrbuch*, and founded a special department for minor planets, which subsequently developed into the Astronomisches Recheninstitut.

He kept the observational work of the Berlin Observatory at a high level. Knorre, Becker, Küstner, and Battermann were among his assistants. The instruments included a meridian circle, an equatorial, and a new universal transit instrument, with which Küstner made a series of observations that played an important part in the discovery of latitude variation (*M.N.*, **56**, 301). Once this had been detected, Foerster took the lead in organising the international latitude stations. His "Notice Justificative" is printed in *M.N.*, **56**, 283.

He took a keen interest in a wide range of physical questions, especially geodesy, and the adoption of an international system of weights and measures: he organised a system of time-signals and time-balls on the coast.

The following are a few of his published writings:—*Kepler and the Harmony of the Spheres*, 1862; *Encke's Comet*, 1867; *Tiede's Electromagnetic Escapement*, 1867; *The Better Organisation of Telegraphic Announcements*, 1881; *The November Phenomenon* (*Leonids*), 1866; *The Meteors of November* 1872 (*Bielids*); *Ancient and Medieval Astronomy compared with recent Developments*, 1861.

In pursuance of his aim to popularise astronomy, he founded the review *Urania* in 1888, and in 1891 started the *Vereinigung von Freunden der Astronomie und Kosmischen Physik*. He retired from the Directorship of the Observatory in 1904, but retained his University Professorship for some years longer. He died at Bornim on 1921 January 18, at the age of 88.

He had married Ina Paschen in 1868, and had three sons and two daughters. His wife died in 1908.

He was elected an Associate on 1866 May 11, being our oldest Associate at the time of his death.

Magnus Nyrén, who died on 1921 January 16, at the age of 83, was a member of the staff of the Poulkovo Observatory for 40 years, and was eminent for his skill in observing with the instruments of position and in deducing from observations made with them results valuable to fundamental astronomy. He was a Swede, born at Brunskog on 1837 February 21. He entered the University of Upsala in 1859, and took the Doctor's degree ten years later, the thesis necessary for his graduation being on the subject of the Precession Constant. After a short period of work under Swanberg at the Observatory of Upsala, Nyrén joined the staff at Poulkovo in 1868, and was made Adjunct-Astronomer in 1871. In 1886 he was raised to the official position of Vice-Director, which he held until his retirement in 1908.

At Poulkovo Nyrén made observations with the Meridian Circle, the Prime Vertical Transit, and the Great Vertical Circle, and was responsible for the organisation of the work with these instruments. The results of his labours will be found largely in the volumes of Poulkovo observations, but in addition his quality may be judged from a statement of some special personal contributions to the science. In 1870 he published an investigation of the "Constants of Precession" derived from observations of faint stars, the values showing some differences from those found earlier by Bessel and Struve. To account for this he made the suggestion that the cause might be found in a difference in the personal equation of the observers for bright and faint stars, which was an early idea of the now well-established magnitude equation. A second suggestion that the discordance was caused by an actual rotational movement of the bright stars as a whole relative to the faint stars was ingenious and interesting, but was considered by him to be too speculative to be definitely urged. In 1872 he published a "Determination of the Nutation of the Earth's Axis," and in the next year a paper on the "Latitude of Poulkovo," in the course of which he points out small differences in the mean latitude resulting from observations made at the Imperial Observatory at different dates, and he was led to propose to certain astronomers that a systematic investigation should be made to detect possible variations in this co-ordinate. The suggestion was not carried out, but in 1893, after Mr. Chandler had begun his well-known investigations, Nyrén examined the results obtained with the Poulkovo vertical circle during the years 1882–91, and found that they satisfactorily confirmed the period of latitude variation of 430 ± days, and then re-examined some observations made in 1875-79 with the large transit in the prime-vertical for a purpose to be immediately mentioned, and found that they also corroborated this period of variation. The result of the research with the prime-vertical transit just mentioned, "l'Aberration des Étoiles fixes," appeared in the *Memoirs of the St. Petersburg Academy*, **19**, 1883, and caused some special interest. The value of the constant of aberration, 20″·445, found by W. Struve had been accepted for many years as trustworthy until other and further investigations had led to the surmise that it required a positive correction of several hundredths of a second. Nyrén therefore undertook to make a redetermination with the same instrument and by the same method. The value which resulted from his observations was 20″·517, and, taking the mean of this with others, he suggested 20″·492 in the Memoir cited as a final value of the constant to be adopted. This comparatively large value seemed to demand search as to its cause, and writing in the year 1895 (*Annals of the Cape Observatory*, vol. **6**, "Solar Parallax," vol. i. part 6, p. 21), Sir David Gill says: "A few years ago one would have regarded Nyrén's determination as beyond reproach, but since that time two important facts have been clearly demonstrated, neither of which was considered and provided against when W. Struve planned the system of Prime-Vertical observations which have been so long and so successfully carried out." The two facts were the variation of latitude and magnitude equation. Newcomb also pointed out in his book on *Astro-*

nomical Constants, that the latter cause might have affected the result, but modified his opinion later. Nyrén's observations were made by eye and ear, and were not chronographic. He replied to these criticisms in a short paper published in the *Astronomical Journal* (No. 396) and in the *Bulletin Astronomique* (1897). Other papers on similar subjects are to be found catalogued under his name, the last, published in 1920, being the "Proper Motions of 633 Stars" determined in connection with the formation of *Poulkovo Fundamental Catalogue*. An article on the "Nebular Hypothesis of Kant and Laplace," with a *résumé* of Thomas Wright's "New Hypothesis of the Universe," written by him, will be found in the *Vierteljahrsschrift der Astronomische Gesellschaft* for 1879.

Nyrén married Emilie Wall in 1872, their family consisting of two sons and a daughter. A biographer says of him that in spite of 40 years' activity in the Russian service, he remained a true Swede, and after his retirement went to Stockholm to end his days.

He was elected an Associate of the Society on 1884 November 14.

H. P. H.

Notes on some Points connected with the Recent Progress of Astronomy.

Discovery of Minor Planets in 1921.

52 announcements of discovery were made during 1921, excluding those that have already been identified with known planets.

Letter and Number.	Date. 1921.	Discoverer.	Magnitude.	Letter and Number.	Date. 1921.	Discoverer.	Magnitude.	Letter and Number.	Date. 1921.	Discoverer.	Magnitude.
JB 945	Feb. 3	So	12	JW	Aug. 8	R	13	KR	Oct. 26	R	13
JC 946	11	Wf	13	JX	Sept. 7	R	13	KS	27	P	13
JD 947	8	Sn	13	JY	7	Wf	11	KT	Nov. 4	H	
JE 948	Mar. 3	R	13	JZ	8	R	13	KU	9	Ba	13
JF	5	Wf	13	KA	8	R	13	KV	9	Ba	14
JG	7	R	14	KC	28	R	14	KW	Oct. 25	R	13
JH	7	R	14	KD	30	R	14	KX	Nov. 5	Be	13
JJ	10	Wf	13	KE	30	R	13	KY	25	R	14
JK 949	11	Wf	13	KF	30	R	13	KZ	5	Be	13
JM	13	Ba	15	KH	Oct. 1	R	14	LA	26	Wf	15
JN	Apr. 1	Wf	15	KJ	6	R	14	LB	29	R	13
JO	1	R	14	KK	9	R	13	LC	30	Wf	14
JP 950	1	R	13	KL	9	R	13	LD	23	Ba	15
JR	27	R	14	KM	10	R	14	LE	23	Ba	14
JS	8	Wd	13	KN	25	Wf	14	LF	23	Se	12
JT	29	J	12	KO	25	Wf	16	LG	Oct. 28	Be	13
JU	Aug. 4	R	12	KP	25	R	14				
JV	5	R	12	KQ	26	Wf	14				

The initials stand for: Ba = W. Baade, Bergedorf, Hamburg; Be = S. Beljavsky, Simeis, Crimea; H = J. Hartmann, La Plata; J = E. Jekhowsky, Algiers; P = J. Palisa, Vienna; R = K. Reinmuth, Königstuhl, Heidelberg; Se = A. Schaumasse, Nice; Sn = A. Schwassmann, Bergedorf, Hamburg; So = J. Comas Sola, Barcelona; Wd = H. E. Wood, Johannesburg; Wf = M. Wolf, Königstuhl, Heidelberg.

The following planets, unnumbered at the date of the last Report, have received permanent numbers:—1920 HK, 934; HM, 935; HN, 936; HO, 937; HQ, 938; HR, 939; HT, 940; HV, 941; HW, 942; HX, 943; HZ, 944.

The identity of 770 with Σ50 is confirmed: this planet was observed 1918 Apr. 12, 1921 Mar. 27.

The following identities have been established:—1919 FS = 592 Bathsheba; (as FS had been numbered 919, this number is now given to 1918 EQ); 937 = 1916 ZJ; 1921 JA = 542 Susanna; 1921 JL = 172 Baucis; 1921 KG = 368 Haidea. 1921 JQ, KB proved to be false images.

The following planets have received names:—707 *Steĭna*, 733 *Mocia*, 776 *Berbericia*, 794 *Irenaea*, 796 *Sarita*, 800 *Kressmannia*, 802 *Epyaxa*, 810 *Atossa*, 813 *Baumeia*, 822 *Lalage*, 823 *Sisigambis*, 827 *Wolfiana*, 828 *Lindemannia*, 831 *Stateira*, 834 *Burnhamia*, 836 *Jole*, 846 *Lipperta*, 867 *Kovacia*, 869 *Mellena*, 870 *Manto*, 876 *Scott*, 880 *Herba*, 883 *Matterania*, 888 *Parysatis*, 901 *Brunsia*, 903 *Neuliey*, 905 *Universitas*, 906 *Repsolda*, 907 *Barnardiana*, 911 *Agamemnon*, 914 *Palisana*, 930 *Westphalia*, 945 *Barcelona*. 907 is named in memory of Professor Barnard's wife.

Edzard Noteboom has continued Dr. Witt's researches on the perturbations of Eros by the Earth. His researches cover the whole period 1893–1914, and include the action of all the planets. The value obtained for the solar parallax is $8''\cdot799 \pm ''\cdot001$. He points out the fact that only two observations of Eros for the 1903 opposition are available. It is obviously desirable to observe it carefully at every opposition. It will be fairly near the Earth in the opposition of 1923–24, which is seven years before the very close approach of 1931.

The planets 887 *Alinda* and 944 (1920 HZ) were both observed at a second opposition during the autumn of 1921. The former has a perihelion distance of 1·17 and a period of four years. The latter has a period of 13·67 years, its aphelion being close to Saturn's orbit.

Ast. Nach., 5114, contains researches on the orbit of Patroclus by Herr Dracker.

Mr. Innes notes that some of the planets ascribed to him in last Report should be put to Mr. H. E. Wood. A. C. D. C.

Discovery of Comets in 1921.

The comet Taylor-Skjellerup was followed till February.

1921 *a* = 1921 II. was discovered by Mr. W. Reid at the Cape on March 13; it was of mag. 9, and brightened steadily up to perihelion, when it was a naked-eye object of mag. 5·3. On Apr. 30 a tail 40′ long in P.A. 266°·2 was photographed at Heidelberg. The comet passed within $4\frac{1}{2}°$ of the North Pole and was very widely observed. It was recovered in the autumn by Dr. Baade, who photographed it on Oct. 1, Nov. 2, Nov. 8, Nov. 26 (mag. 16).

1921 *b* = 1921 III. (periodic comet Pons-Winnecke) was detected by Prof. Barnard on Apr. 10, being of mag. 12; it brightened fairly rapidly, and in June was a large and conspicuous telescopic object of mag. 6·5. The orbit deduced from last year's observations shows very large Jupiter perturbations, the perihelion distance having increased since 1915 by some six million miles. A fairly rich meteor shower belonging to this radiant was seen in Japan towards the end

of June.* A few meteors were observed in India, Europe, and America. After perihelion passage the comet was well observed, especially at Johannesburg, being followed till September.

1921 c = 1921 I. was discovered by Prof. Dubiago at Kasan on Apr. 24: it was of mag. 10½, and remained faint and diffused throughout its period of visibility. It was, however, well observed for two months.

1921 d = 1921 IV. (periodic comet Encke) was detected by J. F. Skjellerup and W. Reid at the Cape on July 27, being of mag. 9. It was observed at Johannesburg daily from Aug. 2 to 13 (omitting Aug. 9). It grew faint rapidly and could not be followed longer.

1921 e. We may give this designation to a bright star-like object seen 3° east of the Sun at the Lick Observatory about sunset on Aug. 7. The object was seen at many other places (see *B.A.A. Journal*, vol. 31, No. 10; vol. 32, No. 2), but the positions are too rough to enable the orbit to be found; it is, however, probable that the motion was retrograde and the perihelion distance small. An observation reported from Plauen on Aug. 7 is inconsistent with the others, and possibly referred to the planet Jupiter, though the position given was 5° from it. Some moving luminous streamers seen in the night sky at Heidelberg on Aug. 10 were possibly a tail of this comet, but more probably they were auroral. The following are approximate orbits of five comets. The equinox is in each case that of the beginning of the year of perihelion, *i.e.* 1920 for the first, 1921 for the others; T is in G.M.T.

Comet. Computer.	1920 II. F. E. Seagrave.	1921 I. M. Ebell,	1921 II. Ivanoff.	1921 III. F. E. Seagrave.	1921 IV. L. Matkievitch.
T	June 10·570	May 5·2445	May 9.9560	June 12·9165	July 13·282
ω	186° 41′ 48″	97° 40′ 54″	268° 20′ 21″	170° 17′ 18″	184° 43′ 31″
Ω	120° 47′ 30″	65° 17′ 48″	64° 29′ 18″	98° 6′ 29″	334° 35′ 29″
i	12° 46′ 32″	22° 31′ 16″	132° 9′ 16″	18° 54′ 37″	12° 31′ 4″
ϕ	34° 13′ 0″	...	...	43° 10′ 35″	57° 51′ 21″
log q	0·1195142	0·052702	0·003767	0·017372	9·5314853
log a	0·4783612	...	...	0·518022	0·3459800

The actual T for 1921 IV., corrected by the observations, is about July 13·06. A. C. D. C.

Solar Activity in 1921.

Sun-spots.—The sun-spot activity of 1921 has shown a considerable decline, the mean daily spotted area being half that of 1920. The following table, giving the mean daily areas (corrected for foreshortening) in millionths of the sun's visible hemisphere, indicates the progress of the cycle since the maximum:—

Year.	1917.	1918.	1919.	1920.	1921.
Area	1531	1100	900	700	350

The values given for years after 1917 are provisional.

* See *Observatory*, March 1922, p. 81.

Together with the decline in area, there is also shown the usual equatorward progression of the main belts of activity. No spot group of importance appeared in latitudes exceeding 12°, and the average latitude of all groups was about 8° N. or S. There has also been an increasing number of spotless days. From these indications the next minimum should occur in 1924. Apart from the general decrease in activity, however, there were twelve groups of spots observed during the year, each with an area exceeding 500 millionths of the sun's visible hemisphere. Of these, three were of considerable extent; the largest (1300 millionths) was the naked-eye group of May associated with great magnetic disturbances; the second and third were on the central meridian on June 30 and November 24 respectively. The northern hemisphere appears to have been the more active during the year.

H. W. N.

The Prominences.—The Kodaikánal photographic records show that the mean daily area and mean daily number of prominences during 1921 were almost the same as in 1920, only a slight decrease is indicated.

The mean daily areas in square minutes of arc are as follows:—

	North.	South.	Total.
1921 January to June . . .	1·92	2·70	4·62
July to December. . .	1·76	1·79	3·55

The mean daily numbers decreased from 14·7 in the first half of the year to 13·6 in the second half.

The general distribution in latitude is similar in the two periods of six months and differs somewhat from that obtaining in the previous year. Well-marked zones of activity are shown at about 40° in the northern hemisphere, and at about 25° and 55° in the south. The polar regions remained quiescent.

Metallic prominences were very much less frequent than in 1920 and all were in low latitudes in the sun-spot zones. The great sun-spot of May was accompanied by remarkably bright metallic eruptions, especially on May 19 when the enhanced lines of iron were seen brightly reversed on the disc in addition to the lines of sodium, magnesium, and helium.

Displacements of the hydrogen lines at the limb and on the disc were fairly frequent, and there was the usual great preponderance of displacements towards red on the disc and a smaller excess in the same direction at the limb.

Prominences projected at the disc as absorption markings decreased greatly during the second half of the year. J. E.

Solar Research in 1921.

Sun-spots and Prominences.—A discussion of the distribution in latitude and longitude of sun-spots, prominences, and faculæ for the cycle 1905-17 has been published in the *Annales de l'Observatoire de Zô-Sè*, 12. This cycle does not show the dissymmetry between the

east and west hemispheres found for earlier cycles at Greenwich (A. L. Cortie, *Observatory*, **44**, 121). On the other hand, J. Evershed and P. R. C. Aygar (*Kodaikánal Bull.*, **67**) find some evidence of an earth effect on the distribution of prominences in the same cycle (1904-16). Their results are, however, opposed to the previous views that the earth tends to extinguish a prominence. G. E. Hale (*Pop. Ast.*, **29**, 625) has examined sun-spot spectra for evidence of the Stark effect due to an electric field, but without success. He gives reasons why the effect should not be observable. In addition to the usual annual accounts of sun-spot and prominence activity at Lyons, Kodaikánal, Mount Wilson, S. D. Tscherny has published (*M.N.R.A.S.*, **81**, 520) figures for the years 1916-20. O. T. Lee has given an account (*Ap. J.*, **53**, 310) of a prominence on 1920 October 8 which reached the record height of 831,000 km. H. N. Russell (*Ap. J.*, **54**, 293) discusses the temperature gradient which would obtain in sun-spots if their cooling is to be ascribed to expansion. M. d'Azambuja (*C.R.*, **173**, 1450) gives an introductory account of work being taken up at Meudon on the distribution and total and partial movements of filaments.

Displacement of Spectral Lines.—C. Fabry and H. Buisson (*C.R.*, **172**, 1020) have re-examined old measures of iron lines in the arc and the solar spectrum and find a displacement to the red, not otherwise accounted for, rather larger than the Einstein effect. A. Perot (*C.R.*, **172**, 578), working on the pressure effect in the solar magnesium spectrum, finds very low pressures and an outstanding shift to the red, best explained by the Einstein effect. On the other hand, R. E. de Lury (*Pop. Ast.*, **29**, 154), from a study of 2 iron lines, 3 magnesium lines, and 33 cyanogen lines, finds the effect only in the iron lines and prefers to accept the absence of the effect in the other lines as being the more trustworthy results. Julius (*Ap. J.*, **54**, 92) examines the limb-centre shifts of 866 lines and finds them affected by the presence of close companions. He attributes his results to anomalous dispersions and denies the presence of the Einstein effect.

Solar Spectrum.—C. Fabry and H. Buisson (*Ap. J.*, **54**, 297) study the solar spectrum in the ultra-violet from λ3150 to λ2900. F. S. Brackett (*Ap. J.*, **53**, 121) gives a study of the infra-red spectrum of the sun for the range λλ8900–9900. Only about fifty lines of solar origin were found with wave-length greater than λ8900. H. N. Russell (*A.S.P.*, **33**, 202) announces the discovery of the strong arc-lines of rubidium in sun-spot spectra, a result foretold by M. N. Saha.

Solar Periodicity.—A. Schmidt (*A.N.*, **214**, 419) discusses a period of thirty days from magnetic observations.

Eclipse Results.—An unsuccessful attempt to photograph the bright-line spectrum of the lower chromosphere at the partial eclipse of 1921 April 7 is recorded by Newall (*M.N.R.A.S.*, **81**, 482).

Solar Radiation.—N. Kalitin (*A.N.*, **214**, 17) suggests a variation of the solar constant depending on the earth's solar latitude. E. A. Milne (*M.N.R.A.S.*, **81**, 361, 375, 510) examines the conditions for radiative equilibrium in the *outer* layers of a star, the theoretical spectral distribution for a star in radiative equilibrium, and the effect of a strong absorption line on the distribution of energy over the spectrum :

the redistribution over the spectrum involves a slight shift of the maximum towards the violet.

Solar Rotation.—H. F. Newall (*M.N.*, 82, 101) discusses in terms of turbulent motion the evidence against the consistent presence of Faye's law of solar rotation. He suggests that the law changes with the solar cycle. He makes suggestions (*ibid.*, 115) as to a new method of securing spectroscopic observations of the sun's rotation.

F. J. M. S.

Stellar Spectroscopy in 1921.

Nebulæ.—V. M. Slipher (*Pop. Ast.*, 29, 272) quotes spectroscopic evidence in support of van Maanen's rotating nebulæ. He also reports the discovery of two spiral nebulæ with very large radial velocities, 1300 and 1800 km./sec. away from the solar system. J. H. Reynolds (*M.N.R.A.S.*, 81, 410) discusses the varying distribution of hydrogen and the unknown gas, which gives the line λ3727, in the region of the Orion nebula.

Novæ.—A. Brill (*A.N.*, 213, 149) discusses some spectra of Nova Geminorum II., 1912, taken by Eberhard at Potsdam. Plates taken in April 1914 show λ4686, Hγ, Hδ as the strongest lines—a typical Wolf-Rayet spectrum. Good details are given of the ultra-violet spectrum in 1912–13. W. H. Wright (*M.N.*, 81, 192, 501) suggests a law for the displacement of the hydrogen lines in Nova Geminorum II. in the form $\Delta\lambda = A\lambda + B\lambda^2$. W. H. Wright (*M.N.*, 81, 181) gives the evidence for the presence of bright enhanced nitrogen lines in the same star in 1913 February 10–March 6. He refers to one band at λ3484, which A. Fowler (*ibid.*, 189) traces also to enhanced nitrogen.

W. E. Harper (*R.A.S. Canada*, 15, 57) confirms the displacement to the violet of the centres of the bright bands in Nova Aquila III., 1918. J. H. Moore (*A.S.P.*, 33, 218) reports that the sinuosity of the bright bands in this star remains unchanged, but that the most displaced maxima are increasing in intensity relative to the central maxima. The rate of growth of the disc, now 5″ in diameter, is slowing down. A. L. Cortie (*M.N.R.A.S.*, 81, 438) discusses the ultra-violet spectrum of Nova Aquilæ on 1918 June 10, and in the *Annales de l'Observatoire de Zô-Sè* objective prism spectrograms of July–August 1918 are discussed.

W. H. Wright (*Lick Obs. Publ.*, 14, Pt. 1) commences a volume of studies of nova spectra from plates secured at the Lick Observatory, with Nova Ophiuchi, 1919. It is noteworthy that the bright α Cygni stage with dark companions on the violet side is found two months after the star's first known maximum.

J. W. S. Lockyer and D. L. Edwards (*M.N.*, 81, 173) discuss objective prism spectra of Nova Cygni III., 1920, during the period 1920 November 2–1921 January 5. The star was below 9th magnitude. A few metallic lines survive, but the spectrum was mainly nebular. The nebular lines first appeared between 1920 October 16 and October 21 (J. A. Parkhurst and E. B. Frost, *Pop. Ast.*, 29, 224). Hα retained its special brightness, but Hβ fell in strength. W. E. Harper gives a

summary of his measures of bright bands and absorptions in August and early September 1920 (*R.A.S. Canada*, **15**, 150), while F. J. M. Stratton gives details of the displacements of the dark lines and the structure of the hydrogen lines for September (*M.N.*, **82**, 44). F. Storey (*M.N.*, **81**, 141) draws attention to the great intensity of this nova's spectrum in the ultra-violet, especially between Hν and $\mu\mu$ 330.

K. Lundmark examines T Coronæ (the nova of 1866) and finds it to be a star of type Ma with bright lines at H$_\beta$, 4686 and one or two other lines (*A.S.P.*, **33**, 271). His results do not quite agree with those of W. S. Adams and A. H. Joy (*ibid.*, 263), who discuss this star along with two other M-type stars with bright lines.

Special Studies.—H. H. Plaskett (*Nature*, **108**, 209) announces the discovery in 9 Sagittæ, Oc, and 10 Lacertæ, Oe5, of the ionised helium lines predicted by Bohr as existing close to the Balmer series, completing the Pickering series. C. D. Perrine (*M.N.*, **81**, 142) draws attention to the behaviour of λ4650, compared with $\lambda\lambda$4634, 4641 in Wolf-Rayet stars.

R. K. Young (*Victoria Astrophys. Obs.*, **1**, 17) in discussing the calcium lines in early-type stars decides in favour of a surrounding envelope coming at a definite stage in the star's development. M. L. Humason and P. W. Merrill give lists of B stars with Hα bright (*A.S.P.*, **33**, 112, 263).

W. H. Wright (*Lick Obs. Bull.*, 332) gives measures of the ultra-violet spectrum of α Cygni up to λ3245; enhanced metallic lines are present throughout. An important additional note by W. W. Campbell states that Hα in the spectrum of α Cygni is bright with a dark companion on the violet side, displaced more than is consistent with the behaviour of the other lines of the spectrum. W. J. S. Lockyer and D. L. Edwards (*M.N.R.A.S.*, **81**, 495) show that ϕ Cassiopeiæ is a giant star intermediate between α Cygni and γ Cygni.

W. S. Adams and A. H. Joy (*A.S.P.*, **33**, 107) describe the spectrum of o Ceti near minimum. Bright hydrogen, helium, and iron arc lines are found. The hydrogen lines become complex in structure. A suggestion of shells placed unsymmetrically with respect to the nucleus is given to account for a curious asymmetry in the spectrograms.

P. W. Merrill (*A.S.P.*, **33**, 206) explains the differences and the resemblances between the spectrum of R Cygni and that of the red stars to whose light-curve its own corresponds. The same writer (*Ap. J.*, **53**, 185) discusses the different stages in the light-cycle of red stars at which various arc lines of iron and magnesium brighten, and in the particular case of R Aquarii (*Ap. J.*, **53**, 375) notes that the nebular and helium lines do not share in the change of intensity exhibited by the starlight, and also give different velocities to that of the absorption spectrum of the star.

M. Salet (*C.R.*, **173**, 828) gives a spectrophotometric study of K stars, showing that compared with solar stars they are one magnitude fainter in the blue than in the green.

W. S. Adams and A. H. Joy call attention (*A.S.P.*, **33**, 206) to the fact that Antares, a star of Class M, has a companion of Class B3.

F. C. Leonard (*ibid.*, 214) refers to another pair, Σ2245, with spectra G5 and B9.

W. M. Worssell (*Union Obs. of S. Africa, Circular* 52) reports that spectrograms taken over three years fail to show the bright hydrogen lines reported from Harvard; also η Centauri has dark lines on the violet side of bright Hβ and Hγ, while Hα has a dark companion on the red side. A list of newly discovered stars with peculiar spectra is given in *Harvard C.O. Circular*, 224.

S. Albrecht (*Ap. J.*, **54**, 161) discusses the periodic changes of spectral type and wave-length, cleared of velocity corrections, in the cycle of changes of a Cepheid variable. Strengthening or weakening of faint companions is given as the chief factor present. Albrecht further notes systematic increase of period as the type becomes later.

Radial Velocities.—J. Lunt (*Cape Annals*, **10**) gives a list of 120 radial velocities determined at the Cape. W. Heiskamen and H. Ludendorff (*A.N.*, **213**, 297) note that stars of the o Ceti type, like the Cepheid variables, have larger radial velocities when the periods are shorter.

Spectroscopic Binaries.—Orbits of 32 binaries have been published, mostly from Mount Wilson, Ottawa, Victoria, and Santiago. The results appear in observatory publications or in the *Astrophysical Journal*, *Popular Astronomy*, or the *Astronomische Nachrichten*. J. Lunt (*Cape Annals*, **10**) discusses the variable orbit of 42 Capricorni. Its period is decreasing and its apse line rotating. The disturbing third body is invisible. W. E. Harper (*R.A.S. Canada*, **15**, 148) withdraws the provisional elements given in 1919 for ν Geminorum. J. S. Paraskévopoulos (*Ap. J.*, **53**, 149) claims that 65 τ Cygni with a period $0^d.142$ has the shortest known period. The separation comes out too small for the star to be a simple binary; F. Henroteau finds a similar difficulty in suggesting (*Ottawa*, **5**, No. 3) that Maia is a binary with a period of about two hours. Henroteau also finds that γ Eridani has a varying orbit. Reference to fixed calcium lines occurs for HR 8427 and γ Cygni (J. S. Plaskett, *Victoria*, **1**, 11), for HR 8803 (S. L. Boothroyd, *Victoria*, **1**, 19), and for δ Orionis (Hnatek, *A.N.*, **213**, 17). In the last-named case a possible application of the Einstein effect in this connection is discussed. In TX Herculis J. S. Plaskett (*Victoria*, **1**, 15) finds that the spectroscopic phase lags behind the photographic. R. H. Baker (*Pop. Ast.*, **29**, 146) shows that the bright hydrogen lines have narrow absorptions superposed which share the fine H and K displacements.

Instruments.—T. R. Merton (*Proc. R.S.*, **99a**, 78) suggests the use of a grating crossing an objective prism and placed between it and the object-glass for the purpose of determining the distribution of thermal radiation in a star.

Classification.—Miss A. E. Cannon (*Harv. Ann.*, **94**, 95) carries the new Draper Catalogue to $14^h\ 59^m$.

Stellar Atmospheres.—H. Deslandres and M. Burson have now traced the lines H_3, K_3 (as well as H_2, K_2) in ϵ Geminorum and α Orionis, where they are strong relative to the sun (*C.R.*, **172**, 405 and 729). In several other stars of type G, K, and Ma the lines H_2 and K_2 have also been observed. M. N. Saha (*Proc. R.S.*, **99a**, 135) applies his theory of thermal ionisation and radiation to the task of placing the stars in an orderly sequence depending on temperature as the chief differentiating factor. A critical account of Saha's work is given by E. A. Milne (*Observatory*, **44**, 261). Saha also applies his views to a discussion of the cause of the stationary H and K lines, invoking selective radiation to drive the atoms out to form an outer atmosphere. F. Henroteau (*R.A.S. Canada*, **15**, 62) discusses the same problem, and also the behaviour of Hϵ in σ Cygni, which suggests anomalous dispersion through a calcium cloud.

Miscellaneous.—C. Laplace-Janssen and A. Haarh (*A.N.*, **214**, 383) show that the N-stars are flattened in distribution on to the galaxy, while the R-stars are spherically distributed. For the R-stars the absolute velocities are small and the K-term large. O. Kohl (*Phys. Zeit.*, **22**, 665) examines the Taurus stream of stars, and with the aid of certain assumptions separates the working of the Doppler and Einstein effects, deducing the presence of the latter effect. F. J. M. S.

Saturn, 1920–21.

The passage of the ring-plane of Saturn across the Earth's orbit (1920 October to 1921 August) occurred under favourable circumstances. Good observations were obtained at the time of the first two passages of the plane through the Earth (1920 November 7, disappearance; and 1921 February 22, reappearance) and of the passage through the Sun (1920 April 8 to 11, disappearance). The third passage of the plane through the Earth (1921 August 3, reappearance) took place under conditions not unfavourable for observations in the Southern Hemisphere, but no published results are to hand.

On 1920 November 6, $17^h{\cdot}0$ the ring was easily visible. On November 7 at $16^h{\cdot}5$ no trace of the ring could be seen by M. A. Ainslie (Greenwich, 28-inch refractor) or at $22^h{\cdot}0$ by E. E. Barnard (Yerkes, 40-inch refractor). The predicted time of passage was November 7, $5^h{\cdot}0$. A period of unfavourable weather followed, and the rings were not again seen till November 13, when Barnard found them feebly visible in the 40-inch refractor. By November 21 they were visible in instruments of moderate aperture.

For a week before 1921 February 22 no trace of the ring could be seen by K. Graff and other observers using refractors of 24 inches aperture and upwards, under favourable observing conditions. The predicted time of passage was February 22, $9^h{\cdot}0$. K. Graff (Bergedorf, 60-cm. refractor) found the rings fairly easy at $8^h{\cdot}0$, and he and other observers noticed that they brightened steadily as the evening advanced. E. C. Slipher (Lowell Observatory, 24-inch refractor) was, however, able to

photograph the rings on February 20 and 21 at 21^h on each evening, and found them to have already brightened considerably by the later date. It would seem, therefore, that the actual passage of the earth through the ring-plane occurred over twelve hours before the predicted time. These remarkable photographs show the full outer extension of the ansæ, but the region of the crape ring is obliterated by the over-exposed image of the planet.

The chief interest of observations made while the Earth is near to the ring-plane of Saturn lies in the opportunity afforded for obtaining information as to the thickness of the rings and any irregularities in their contour. E. E. Barnard regards his November observations as demonstrating "how incredibly thin the rings must be. . . . Russell's estimate of their thickness (about 21 kilometres) . . . seems reasonable" (*P.A.*, 29, 148). W. H. Pickering, on the other hand, observing with an 11-inch refractor at Mandeville, Jamaica, considers that his observations made at the time of the November disappearance indicate a thickness of the crape ring of the order of 1000 miles, and that other observations made at the time of the passage of the plane through the Sun in April indicate a thickness of the order of 400 miles.

While the Earth is on the unilluminated side of the ring two condensations in each ansa are generally visible. Their positions as measured by E. E. Barnard in 1920 November were found by him to agree closely with those determined under similar circumstances in 1907. These condensations are situated at the projected position of the crape ring and just within the inner border of the Cassini division. They appear to be due to the additional illumination of particles on the dark side of the ring by light passing through the crape ring and the Cassini division.

While the Earth is on the illuminated side of the ring, at times near disappearance or reappearance, bulges are seen on the ansæ, the light in which occasionally appears to be concentrated in bright points. P. H. Hepburn, summarising the observations of B.A.A. observers (*B.A.A.J.*, 31, 226), expresses the opinion that these bulges are irradiation effects, and that the occasional appearance of bright points is purely optical, since they were found to vanish under conditions of best seeing. On February 22 A. Danjon and G. Rougier with the Strasburg 16-cm. refractor observed and measured two such points in each ansa, and found that their positions corresponded, not with the condensations seen when the unilluminated face of the rings is presented, but with the projected positions of the brightest parts of rings "A" and "B," which is confirmatory of the view just stated. K. Graff takes the same view with regard to bright "knots" seen by him at the same epoch.

The observations of 1920–21, made, as they were, under very favourable conditions, give no support to the view that the rings—or the bright rings at any rate—are other than exceedingly thin and of perfectly uniform contour.

On February 22 Danjon and Rougier measured the position-angle of the ring as being $85^\circ\ 14'{\cdot}0$, the *Nautical Almanac* value for the date being $85^\circ\ 20'{\cdot}9$. They remark that the difference is larger than the greatest deviations between the individual measures and the mean.

Photometric measures of the brightness of the rings at dates near February 22 are given by K. Graff (*A.N.*, 213, 29).

The phenomena of the passage of the ring-plane through the Sun (1921 April 8–12) call for no special remark. The rings were then fairly widely open, and the sole effect observed was the gradual fading in brightness and the reappearance of the condensations. At no time did the rings cease to be visible in instruments of moderate aperture. P. H. Hepburn, from observations in twilight made in May and June when the unilluminated ring attained its greatest opening, finds that the rings were then intermediate in visibility between Titan and Rhea.

The satellite phenomena were disappointing. In England no transits, shadow transits, or eclipse disappearances of Titan were visible, and but three eclipse reappearances, all under unfavourable conditions. R. T. A. Innes (*loc. cit.*) gives particulars of observations of eclipses of Titan and Rhea. W. H. Pickering (*P.A.*, 29, 603) describes mutual occultations on 1921 February 20 of Titan–Rhea and Dione–Rhea. On 1921 April 8 an eclipse of Rhea by the shadow of Titan, predicted by L. J. Comrie and A. E. Levin, was successfully observed (*M.N.*, 81, 486).

Following are references to observations furnishing the material for this note :—

E. E. Barnard, 1920 November; *P.A.*, 29, 147.
B.A.A. observers, 1920 October to 1921 February, *B.A.A.J.*, 31, 64, 222; 1921 March–June, unpublished.
E. Bernewitz and G. Struve, 1921 February; *A.N.*, 213, 75.
A. Danjon and G. Rougier, 1921 February; *C.R.*, 172, 523.
E. Delporte, 1921 February and April; *Ciel et Terre*, 37, 63.
K. Graff, 1921 February; *A.N.*, 213, 29, 73.
P. H. Hepburn and others, 1920 November; *M.N.*, 81, 126.
R. T. A. Innes, 1921 April–June; *Union Obs. Circ.*, No. 53.
B. Meyermann, 1921 February; *A.N.*, 213, 29, 71.
W. H. Pickering, 1920 November and 1921 April; *P.A.*, 29, 601; *B.A.A.J.*, 31, 290, 382.
F. Quénisset, 1921 February; *l'Ast.*, 35, 115.
C. E. Slipher, 1921 February; *H.O.B.*, 742.

P. H. H.

List of Public Institutions and of Persons who have contributed to the Library, etc., since the last Anniversary.

(*Institutions exchanging publications with the R.A.S. Library are omitted from this list, in order to economise printing.*)

Amsterdam, Astronomical Institutes of the Netherlands.
Astronomical Society of Japan.
Berne University.
Chicago, John Crerar Library.
Kyoto, University Observatory.
Paris, Bureau International de l'heure.
Tübingen, Oesterberg Observatory.

Signor G. Alliata.
M. Henri Arctowski.
Prof. E. E. Barnard.
Signor G. Boccardi.
Miss A. Breton.
British Optical Instrument Manufacturers' Association.
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M. Paul Stroobant.
Herr H. Struve.
M. H. Vanderlinden.
L. Vegard, Esq.
W. H. Wesley, Esq.
Messrs. Wheldon & Wesley.
Signor G. Zappa.

ADDRESS

Delivered by the President, Professor A. S. Eddington, on the award of the Gold Medal to Dr. James Hopwood Jeans.

The Council have awarded the Gold Medal to Dr. James Hopwood Jeans for his contributions to the Theories of Cosmogony.

The *Philosophical Transactions* for the year 1901 contain two consecutive papers on the pear-shaped figure of equilibrium of rotating liquid masses, the one by Sir George Darwin and the other by Henri Poincaré. The old problem of the succession of forms taken by a spinning mass of liquid was waking into new life; and the discussion as to whether the latest configuration—perhaps rather infelicitously described by the term "pear-shaped"—is a possible stable stage in the development of a star on its way to separation into a binary system, was shortly to become a burning question of the hour. It was at this period that J. H. Jeans, then Isaac Newton Student in the University of Cambridge, entered the ranks of astronomers, and, as was natural to a pupil of Sir George Darwin, became fascinated by the problem which was then opening up.

He had previously published work of great importance on the Dynamical Theory of Gases, a subject on which he is now one of the greatest authorities. I suppose that we must admit that astronomy can only lay claim to half of him—perhaps not even the larger half. Happily the two subjects go well together—an alliance nowhere more strikingly illustrated than in Jeans' researches—so that we lose nothing, and have gained much, by his faithfulness to his first love. And so his first contribution to the problem of stellar evolution called attention to some very different circumstances which arise when account is taken of the fact that actual bodies are compressible and often gaseous. The theory of rotating liquids was an important step towards understanding the behaviour of stars; but Jeans made it clear that much more remained to be done before the results could be applied with any certainty to actual bodies. His paper on the "Stability of a Spherical Nebula" showed that other causes of evolution were at work in a gas besides those allowed for in the more restricted problem of Darwin and Poincaré. This paper was noteworthy as introducing the conception of *gravitational instability*. There is a natural tendency for nuclei to form in an extended nebula and grow by attracting matter to themselves, so that we have another cause of separation of primitive material besides the possible fission through too rapid rotation.

A little later Jeans conceived the idea that it would be a valuable illustration of the behaviour of a rotating liquid mass if the corresponding two-dimensional problem were fully worked out instead of the heart-breaking actual problem of three dimensions. The investigation could

be carried much further, since the mathematical analysis was simplified. He accordingly considered a rotating cylinder constrained always to remain in a cylindrical form. For slow rotation the cylinder is circular, corresponding to the ordinary flattened spheroid in the three-dimensional problem. This is succeeded by an elliptic cylinder and then by the analogue of the pear-shaped figure. The figures were traced much further along this last sequence than had been possible in three dimensions—so far indeed as to show that a furrow was forming which would deepen into a neck. This made it extremely probable that the pear-shaped figure would end in fission into two detached masses, as had been expected. It is at least plausible to suppose that an analogous sequence will occur in the three-dimensional problem. In particular, Jeans examined whether at the start these pear-shaped cylinders were stable; he was able to solve this problem completely—a result of much importance, since the corresponding problem for three dimensions was then undecided and intractable. But, as a Master of Trinity has remarked, we are none of us infallible—not even the youngest. There is a legend that high Wranglers at Cambridge are somewhat shaky at arithmetic. I am loath to add currency to this libel: but it has to be mentioned that, after all the difficult analysis had been successfully carried through, a numerical error in the final step led to a result which was the opposite of that which the investigation had really demonstrated. It was not until 1916 that the mistake was discovered by Jeans himself, and the pear-shaped cylinder found to be always unstable.

The general object towards which these researches are directed is the cosmogonical problem of how the matter of the universe has separated into detached bodies—the stars, the planets, and the satellites. It includes a variety of individual problems: how the planets have become separated from the sun; how the components of a double star have become separated from one another; how the arms of a spiral nebula have been ejected; how a primitive nebula has crystallised into stars. And if the origin of these systems can be traced, the work must be followed up quantitatively with a view to explaining the various uniformities which they show and the statistical distribution of properties. I will not follow further the historical progress of our Medallist's work. We will leave him fairly launched in the most far-reaching of all the problems that confront the astronomer. An interval of sixteen years elapses. We can now turn to his Adams Prize Essay, "Problems of Cosmogony and Stellar Dynamics," to learn the fruition of his efforts. In the interval he had gone on surmounting obstacles. The way to scientific truth is a zigzag road, and opinions had to be modified from time to time. Nor must we forget the new light which, in these sixteen years, had been flooding in by the progress of observational astronomy—the discovery of retrograde satellites, the work of Russell and Hertzsprung on giant and dwarf stars, the extension of the scale of the galactic system by Shapley, the radial velocities of spiral nebulæ, and so on.

The great problem of the stability of the pear-shaped figure of equilibrium is now settled. Darwin believed he had demonstrated its initial stability; Liapounoff, on the other hand, found it to be unstable. Dr. Jeans has confirmed its instability; and, what is more, he has been

able to indicate the precise point at which Darwin was misled, so that we are no longer left uncertain how to decide between conflicting results. The course of evolution of a rotating mass can now be stated as follows:— As the body contracts its angular velocity will have to alter in order to preserve the angular momentum unchanged. At first its form is the well-known "flattened orange." The ellipticity gradually increases until the equatorial diameter is 1·7 times the polar diameter, when a new phenomenon begins; the equator ceases to be circular, and bulges into an ellipse. A star in this stage is ellipsoidal; and it is clear that as it turns round its light will vary. Three variable stars are known whose light-changes may very well be attributed to this cause. The elongation of the equator becomes more and more accentuated until the figure is not far from a prolate spheroid revolving about one of its shorter axes, when another critical point is reached. (The actual ratios of the axes are then 1·89 : ·81 : ·65.) Further development as an ellipsoid is impossible, because although still a figure of equilibrium the equilibrium is unstable. The pear-shaped series branches off at this point, but this also is found by Jeans to be unstable. Thus there is a complete check. Since continuous development is no longer possible, it is obvious that the next step is a cataclysm. The amount of spin is too great for the body to remain stable in any form as a single mass; division must take place with a rush; and when we are next able to take up the history of the body by statical methods we have to deal with two detached masses—the initial stages of a double star. But although the pear-shaped figure is not one in which the star can remain for any length of time, it is important as indicating the course of the cataclysm. I suppose it would not be true to infer that the cataclysm is merely a rapid progress through the series of equilibrium figures; but at any rate that gives the direction in which it starts off. The general dynamical conditions of the break-up have been studied by Jeans, both for this rotational problem and for the corresponding tidal problem, in which the approach of some other body raises tides great enough to part the mass asunder.

It is not enough to deal with theoretical liquid masses. The astronomer wants to know how far these results are maintained when we take into account the non-homogeneous or gaseous condition of actual stars. The modifications caused by compressibility of the material have been very fully considered by Jeans, who has studied models of sufficient variety to straddle all reasonable possibilities. In general the former results apply without significant modification. A series of pseudo-spheroids branches off into a series of pseudo-ellipsoids, and from these in turn unstable pear-shaped figures branch away. The numerical constants are somewhat modified, but the general development is essentially of the same kind. But a new possibility is added to the former theory; and the mass may separate in a new manner which Dr. Jeans calls "equatorial break-up." Owing to the compressibility of the material the protuberance of the equator takes a sharper form, and for sufficient compressibility and sufficient speed of rotation the figure, instead of being a spheroid, becomes like a lens. If this stage is reached, matter is thrown out in a continuous stream from the equator, where there is now a sharp angle.

Accordingly we have at the one extreme the incompressible liquid, which breaks up by elongating itself under excessive spin, the elongated figure becoming furrowed and so dividing into two parts. At the other extreme we have highly compressible matter such as the perfect gas, which never reaches sufficient elongation, but squirts out matter all round the equator and so avoids the impending catastrophe—like the prudent balloonist throwing out ballast to avoid the bump. In intermediate cases it is a tussle between these two forces of separation as to which shall get into operation first and forestall the other; and according as the compressibility is above or below a critical value, the disruption occurs in the second way or the first. Let us now follow the astronomical consequences of this result.

It can scarcely be doubted that the two components of a close double star have been formed by the first kind of separation. We have just stated, however, that this only occurs when the compressibility is small. It cannot happen to giant stars in the state of a perfect gas; the necessary condition is not fulfilled until the star is near the summit of the temperature-curve with a density something like a quarter the density of water. Thus all close binary stars ought to be in the later stages of evolution. There is considerable statistical support for the view that in general the formation of a close binary does not occur until after the earlier giant stages have been left behind. Jeans' investigation gives a very satisfactory explanation of the remarkable predominance of types B and A among spectroscopic binaries;* this is a strong confirmation, for the fact seems inexplicable in any other way. But, as Jeans himself has noticed, some of the Algol variables are close doubles of extremely low density, and the rule ought to have sufficient elasticity to provide for these exceptions. Some guesses may be made at the modifying circumstances which may account for these. Among them we have still to reckon with radiation-pressure, which is undoubtedly a prominent factor in breaking up gaseous matter under other circumstances. Whether it has much effect in the particular problem of rotational fission is more doubtful; and Jeans' preliminary investigations rather tend against this solution. But a full discussion of radiative equilibrium combined with rotation is a problem offering great difficulty. Personally I find it difficult to resist the opinion that in dealing with the disruption of diffuse gaseous masses, compelled as we are by mathematical exigencies to leave out radiation-pressure, our playbill is like that which "announced the tragedy of *Hamlet*, the character of the Prince of Denmark being left out."

I should mention here that Dr. Jeans distinguishes the close binaries, which we have been considering, from wide double stars. The separation of a double star can increase a little, but only a little, after it has been formed. Close pairs do not turn into wide pairs. Stars forming wide pairs are regarded by Jeans as merely adjacent nuclei in the general formation of stars in a nebula. Although no hard-and-fast line can be drawn, there is obviously a general distinction between pairs which

* The later dwarfs are usually too faint to be observed; the earlier giants cannot have divided; this leaves only the stars at the top of the temperature-curve to provide the observed spectroscopic binaries.

represent centres of condensation in a continuous nebula, and pairs formed later by division of a more or less coherent stellar mass.

Turning now to the second mode of break-up by equatorial emission, we must look for an entirely different kind of effect. It naturally suggests itself that, if the first mode results in a double star, the second mode should result in a single star attended by a system of much smaller bodies on the model of the solar system. But after full consideration this conclusion is rejected by Jeans. The reasons cannot well be summarised. They are different from those which have led other writers in recent times to reject Laplace's nebular hypothesis—those difficulties being, according to Jeans, not insurmountable. Although his demonstration is necessarily not rigorous, it shows that most unlikely conditions would have to occur before the ejected matter could constitute itself into the system of planets which we know.

Accordingly, for an illustration of equatorial rupture we have to look further afield; and it is suggested that in spiral nebulæ the phenomenon is occurring before our eyes. The emission may begin either in the stable spheroidal stage or in the stable ellipsoidal stage of the evolution. If the ellipsoidal stage is reached before equatorial rupture, the ejection will occur at two points only, the ends of the longest axis; we have then the condition which may account for the two arms of outflowing matter in spindle-shaped or spiral nebulæ. I gather, however, that Dr. Jeans is more inclined to attribute the spiral nebulæ to emission occurring in the earlier spheroidal stage. Although in ideal conditions the matter would be emitted from the spheroid symmetrically all round the equator, a very small disturbance from perfect symmetry—say the tidal force due to very distant masses—would suffice to locate the outbreak at two opposite points on the equator. He thus obtains the two arms of out-streaming matter seen in all spiral nebulæ, and these arms would, of course, become curved under the rotation like a gigantic catherine-wheel. He shows, moreover, that the jets would become longitudinally unstable, tending to condense along the spiral knots which he takes to be the nuclei of stars.

There are many comparisons of theory and observation which make this one of the most fascinating parts of our Medallist's work. His problem is now on the grandest scale, dealing with masses comparable not with a star but with a million stars, and the evolution is the evolution of a star-system. That it is a problem in which rotation plays a significant part must be obvious to anyone who has glanced at a spiral nebula—not to mention the direct proof of a high speed of rotation given by line-of-sight velocity determinations; so that it is essentially a problem to which Jeans' theoretical studies of rotation are specially relevant. I cannot refrain from putting here the question which many of you must have asked yourselves: Why are all these great masses endowed with rapid rotation? To say that it is merely the resultant of original chaotic motions, becoming accentuated as the mass contracts, seems to me quite unsatisfying. Is it not the indication of some cause not yet traced which tends to increase the rotation of a body extended in space? Astronomy has had to find a new source of energy for the stars; will it have to find a new source of angular momentum for the nebulæ?

By one of the ironies of science, the study of the break-up of a mass by rotation has taken us on a tour round the universe, finding an application seemingly to every cosmogonical problem except the one which it was originally called in to explain, viz. the development of the solar system. As to the solar system, I will quote Dr. Jeans verbally: "It is probable, though by no means certain, that we must abandon the nebular hypothesis of Laplace." Probable, but by no means certain: many writers would have stated the conclusion more strongly, but I think the reservation was wise; and if, for the sake of brevity, I sometimes have to speak more dogmatically, I trust it will not be inferred that I disregard our Medallist's warning. Going forward on the strength of this probability, we have to consider what other conceivable cause can have led to the development of the system of planets. Apparently only one such cause remains; the disruption must have been started by a large tidal distortion of the sun caused by the close approach of some other large mass in the remote past. On examining this hypothesis it appears to lead to a satisfactory explanation—the planets were formed as condensations in an arm of matter thrown out towards the passing mass. I may add here that it is a feature of Jeans' work that he has treated in parallel development the two problems of rotational and of tidal disruption, much of the mathematical analysis being common to both. Thus it is possible to compare readily the two agencies and to test which is the more likely to have been concerned in any observed phenomenon.

I will quote from Dr. Jeans' summary of his theory: "We conjecture that something like 300 million years ago our sun experienced an encounter of this kind, a larger star passing within a distance of about the sun's diameter from its surface. The effect of this, we have seen, would be the ejection of a stream of gas towards the passing star. At this epoch the sun is supposed to have been dark and cold, its density being so low that its radius was perhaps comparable with the present radius of Neptune's orbit. The ejected stream of matter, becoming still colder by radiation, may have condensed into liquid near its ends and perhaps partially also near its middle. Such a jet of matter would be longitudinally unstable, and would condense into detached nuclei which would ultimately form planets. The more liquid planets at the end of the chain would be those of smallest mass; the gaseous centre would form the larger planets Jupiter and Saturn. Owing to the orbital velocity which had been communicated to these planets by the attraction of the passing star, they would not fall back into the sun, but would describe elliptic orbits, passing fairly near to the sun's surface at their closest approach. As they passed relatively near to the sun, the same process as resulted in the formation of planets out of the sun may have resulted in the formation of satellites out of the planets."

If, indeed, the sun could not give birth to the planets without calling in the aid of a neighbour, a conclusion follows which can only be described as sensational. It is obvious that to distort the sun beyond stable limits and cause the ejection of planet-building material the approach of the passing star must have been a close one; Jeans has elsewhere given as an upper limit a distance of three times the radius of Neptune's orbit. Moreover, a quick approach and recession would be no

use ; the sun and the star must have been travelling with small relative velocity, the one slowly overtaking the other. Such an encounter is statistically improbable. The chances that this cataclysm could happen to any particular star are very small. I think that Dr. Jeans had in mind a length of life of the star shorter than that which would be accepted to-day, so that he may have overestimated the improbability. But at any rate the production of a planetary system is not the normal destiny of a star ; it can only happen to a small proportion of particularly lucky—or unlucky—individuals.

I suppose that nothing in astronomy has appealed more to human imagination than the conception of each of the myriad points of light in the sky as a sun giving warmth and life to an attendant circle of planets. Although we now know that something like half the stars are binary suns, where planets would be a superfluous and uncomfortable complication, we are still left with some thousand million orbs where an abode of life might be provided. It has seemed a presumption, bordering almost on impiety, to deny to them inhabitants of the same order of creation as ourselves. But we forget the prodigality of Nature. How many acorns are scattered for one that grows into an oak? And need she be more careful of her stars than of her acorns? The Economy Axe has not fallen on her department. If, indeed, she has no grander aim than to provide a home for her pampered child Man, it would be just like her methods to scatter a million stars whereof but two or three might happily achieve the purpose.

Let me repeat that Dr. Jeans does not claim to have *established* that our solar system is a freak system, unusual and possibly unique in the universe ; but he has shown how very shaky is the foundation of the opposite view which expects a system of planets to be the normal appanage of a star. Double stars are abundant in the heavens, and the cosmogonist must admit failure if he does not account for them as a *normal* process of development ; he is under no such obligation with regard to planetary systems, of which only one specimen is known to us, which may quite possibly be unique.

Connected with this part of the subject are Dr. Jeans' contributions on the radiative equilibrium of stars. I will not give details, because this has been the subject of vigorous controversy between us ; and on this occasion our long-suffering Medallist is forbidden to defend himself. The *Monthly Notices* records how we have hurled at each other mathematical formulæ—the most undodgeable of missiles, when they are right,—and the onlooker will perhaps conclude that *someone* was badly annihilated. But it is possible that Jeans and I may still have a difference of opinion—as to precisely whose corpse lies stricken on the field.

I pass on now to his researches on stellar dynamics—the consideration of how the individual motions of the stars are influenced by the attractions of other stars or of the stellar system as a whole. One of the most fundamental of these problems is the consideration of a system in a steady state, *i.e.* when the orbits of the stars under the attraction of the whole mass are so distributed that the density and the distribution of velocities remain constant at each point. Such a system is accordingly permanent, except in so far as chance approaches of one star to another

very slowly alter the original distribution of the orbits. I do not think that Jeans or the other investigators attacked this problem with any preconceived idea that the actual universe is a permanent system of this kind; but, a new department of theoretical mechanics being opened up, we have to tackle the easier problems on the road to the more difficult ones, and treat steady systems before collapsing systems.

Dr. Jeans' leading contribution is an elegant mathematical formula, giving one of the conditions for a steady state in a form capable of very general application. I am sorry that this cannot be explained without introducing some mathematics. We shall describe the system fully if we give a formula saying how many stars (N) at each point (x, y, z) are moving with velocity (u, v, w) for all values of x, y, z, u, v, w. That is to say

$$N = f(u, v, w, x, y, z).$$

The function f is called the frequency-function. What Jeans proved was that, if the system is in a steady state, the frequency-function must be a function of the first integrals of the equations of motion. I must explain that if we follow the motion of any particular star of the system, there are certain quantities (functions of its position and velocity) which remain constant throughout its orbit; we call these functions the first integrals. In general there is only one first integral—the sum of the kinetic and potential energies; and Jeans' theorem shows that for a steady state the possible range of frequency-functions which need be considered is very limited, since they must depend only on this integral and not on any other of the multitudinous combinations of x, y, z, u, v, w. But when the system has a certain amount of symmetry there are additional integrals offering greater possibilities: by the aid of the formula these possibilities can be classified and exhaustively discussed.

In a very simple manner Jeans deduces from this formula some striking results. If the distribution of the *stars* has no axis of symmetry, the distribution of their *velocities* must have complete spherical symmetry —there can be no preferential directions of motion. If the distribution of the stars has an axis of symmetry, the distribution of their velocities at any point may also have an axis of symmetry pointing in the transverse direction; thus, if the stellar system is symmetrical about the axis joining the poles of the Milky Way, there may be star-streaming in the galactic plane not in the radial direction but in a transverse direction. Finally, if the distribution of the stars has complete spherical symmetry, the distribution of velocities can be ellipsoidal. The symmetry of mass-distribution and the symmetry of velocity-distribution in a steady system are in a curious way complementary; the more symmetry there is of one kind, the less is needed of the other kind.

If we could assume that the actual universe was in a strictly steady state, these results would settle at once the controversy of radial *versus* transverse star-streaming. Some writers have held that the star-streaming is in the line towards and away from the centre of the galactic system; others have held that it is in the direction of a circular motion, direct and retrograde, about the centre. We see now that only the latter solution is possible in a steady system. For my own part, I think it is

intrinsically improbable that a condition of transverse star-streaming could originate; it has none of the simplicity of Professor Turner's explanation of radial star-streaming. I would therefore regard Jeans' result as strongly suggestive that our galactic system is far from having arrived at a steady state—an alternative interpretation which our Medallist himself fully recognises.

Whilst the foregoing work is his most distinguished contribution to stellar dynamics, for general utility we should pick out another result which was indispensable for progress and is very widely quoted. I refer to his calculation of the average deviation produced in a star's motion by the chance approaches of other stars. I suppose that this was child's play to an expert in the theory of gases; but I know from experience that there is an awkward point in the calculations where the formulæ seemed to become indeterminate, and Jeans succeeded in sailing smoothly over this obstacle. Probably he never noticed it, but that was because he took instinctively the right point of view. I will state his results. Imagine a number of widely separated stars initially moving parallel to one another as in a moving cluster. After 100 million years their directions of motion will on the average deviate by only 10′. That is the whole effect of the casual approaches of other stars, except that in addition 1 star in 8000 will have had exceptional bad luck in experiencing a violent deflection. After 3000 million years the average deviation will be 1°; and further, 1 star in 250 will have been turned aside by more violent encounters, so that it must be counted as lost to the cluster. It is not until after nearly 100,000 million years that the group shows serious symptoms of dissolution; by that time $\frac{1}{10}$ of the original members have strayed away, and the motions of the remainder are deviating to the extent of 5° on the average. With these figures it becomes easy to understand how the stars forming moving clusters have preserved equal and parallel motions notwithstanding the disturbance caused by other stars interloping among them.

Several of the moving clusters are of a distinctly flattened shape—a feature which is particularly noticeable in the Ursa Major cluster. Jeans has shown that this would naturally occur as the result of the gradual scattering by chance encounters. A paper at our meeting last month shows that he is still occupied with this subject, endeavouring to work out the details for a quantitative comparison with observation.

In his theories of the evolution of celestial objects and of the stellar universe as a whole Dr. Jeans has been a bold speculator. We are grateful that it is so. He might have retired among his mathematical models, where the materials behave as he ordains, and muddly old Nature cannot interfere. There is always an attraction to the mathematician in unimpeachable logical deduction, where the premises are explicitly assigned and the conclusion follows of a certainty. The problems of Nature are different; there we are given, say, half the premises and a quarter of the conclusions, not as fixed data but with varying degrees of probability. The binding chains, forged of rigorous logical reasoning, are needed here just as much as in the problems of pure mathematics; it is the anchorage at either end which is perilous. We are glad that Jeans has engaged on the bolder adventure. When,

for example, he had arrived at the instability of the pear-shaped figure, he proceeded at once to risk applying it to reconstruct our views of stellar evolution, instead of following the secure path, and, shall we say, generalising his result for a pear-shaped body of n dimensions. But Jeans' contributions to cosmogony are not to be summed up in snappy sentences—that the solar system was formed by tidal disruption, that a spectroscopic binary cannot be formed until a comparatively high density is reached, that star-streaming must be in the transverse direction, and so forth. How these suggestions will stand twenty years hence, we cannot predict. As Jeans has said: "It has not been part of our task to arrive at a conclusion; the time for arriving at conclusions in cosmogony has not yet come." There are many who think that conclusions of this kind are a measure of the success of an investigator; but they make a great mistake. He is spinning the threads of a great synthesis; and it would be scarcely human, nor indeed scientific, not to cast curious glances at the pattern which is being formed, of which we can gain elusive glimpses. I will not predict how far the final fabric will be like that which we now seem to see through the eyes of our Medallist; but I will predict that in that fabric there are stout threads of his spinning which will not have to be unpicked.

It does not fall within the grounds of this award to describe his great contributions to the kinetic theory of gases and the theory of radiation and of quanta. This, however, has had a twofold influence on his astronomical work. In the first place, the direct application of physics to astronomy and of astronomy to physics is developing so fast that an expert knowledge of the kindred science is most valuable. In the second place, there are problems in astronomy which in their mathematical elements are essentially the same as those which have been treated earlier in the theory of gases, so that the same machinery is required in both sciences. When Dr. Jeans is not studying the stars he is probably to be found studying electrons; and I daresay there may be occasions, in his more mathematical moods, when he is not quite sure which he is studying. The mass of a star is 10^{60} times the mass of an electron, but in certain respects they are much of a muchness. We can contemplate with equanimity his intermittent withdrawal into these more transcendental realms, confident that his love of the stars will always bring him back to earth.

Dr Jeans: I have now the pleasure of handing to you the Medal which indicates the high estimation in which we regard your work. On the one side is figured the great telescope which first revealed so many of the nebulæ and clusters which you have been studying. On the other side is the honoured discoverer of the law of gravitation which is the basis of your mathematical investigations. Through your researches we are beginning to discern the linking of the one with the other. May you long have health and strength to bring further advance to our knowledge.

Election of Officers and Council.

The Meeting then proceeded to the election of Officers and Council for the ensuing year, when the following Fellows were elected: —

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A. S. Eddington, Esq., M.A., M.Sc., F.R.S., Plumian Professor of Astronomy, Cambridge.

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